# Summary Data on Limnology and Food-Web Structure of Great Central, Sproat, and Henderson Lakes, B.C. (2008-2013)

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# SUMMARY DATA ON LIMNOLOGY AND FOOD-WEB STRUCTURE OF GREAT CENTRAL, SPROAT, AND HENDERSON LAKES, B.C. (2008-2013)

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# ABSTRACT

K.D. Hyatt, D.J. McQueen, D.P. Rankin, M.M. Stockwell, and J.R. Ferguson. 2016. Summary data on limnology and food-web structure of Great Central, Sproat, and Henderson lakes, B.C. (2008-2013). Can. Data Rep. Fish. Aquat. Sci. 1262: ix + 94p.

Three nursery lakes (Great Central, Sproat, Henderson) on the west coast of Vancouver Island support a valuable mixed stock fishery for sockeye salmon in Barkley Sound. Given their geographic proximity, the lakes exhibit similar geology, climatology, hydrology, and nutrient dynamics that support a common classification as highly unproductive, oligotrophic, nursery lakes typical of the British Columbia outer coast. All three lakes have long histories as subjects of intentional manipulations, including: introductions of hatchery-origin sockeye salmon fry (Henderson Lake 1910-1935 and 1994-2008), lake fertilization (at Great Central Lake 1970-1972, 1977-present; Henderson Lake 1976-1997, 1999, 2007; Sproat Lake 1985) and variable recruitment of sockeye fry associated with fluctuations in both adult returns and fisheries management objectives (all lakes). Observations of results of manipulations have served to identify some now obvious limitations (e.g. lake size, inorganic nutrient concentration, fry recruitment variations) on sockeye fry utilization of lake capacity to achieve maximum smolt production. However, large differences in this key performance parameter persist between lakes even after the above limitations are taken into account. Research conducted elsewhere suggests that subtle differences in climatology, seasonal nutrient flux and food-web structure between lakes may induce large, persistent differences in their capacity to produce juvenile sockeye. The current report documents detailed methods and data sets associated with several years of work (2008-2013) designed to compare various elements of the physical structure, nutrient status and food-web structure of the Barkley Sound sockeye nursery lakes. Data summarized here will be the subject of further analysis to improve our knowledge of the exact magnitude and sources of between-lake differences in carrying capacity for juvenile sockeye.

# RÉSUMÉ

Hyatt, K.D., McQueen, D.J., Rankin, D.P., Stockwell, M.M., and Ferguson, J.R. 2016. Résumé des données sur la limnologie et la structure du réseau trophique des lacs Great Central, Sproat et Henderson, en Colombie-Britannique (2008-2013). Rapp. stat. can. sci. halieut. aquat. 1262: ix + 94p.

Trois lacs de séjour sur la côte ouest de l'île de Vancouver (lacs Great Central, Sproat, et Henderson) alimentent une pêche rentable de stocks mélangés de saumon rouge dans la baie Barkley. En raison de leur proximité géographique, ces lacs présentent une géologie, une climatologie, une hydrologie et une dynamique des nutriments similaires, ce qui leur vaut la classification commune de lac de séjour oligotrophe très improductif, typique de la côte ouest de la Colombie-Britannique. L'histoire des manipulations subies par ces trois lacs est longue et inclut l'introduction intentionnelle d'alevins de saumon rouge d'élevage (lac Henderson 1910-1935 et 1994); la fertilisation (lac Great Central 1970-1972, puis de 1977 à nos jours; lac Henderson 1976-1997, 1999, 2007; lac Sproat en 1985) et un recrutement variable des alevins de saumon rouge résultant de fluctuations à la fois dans les montaisons d'adultes et dans les objectifs de gestion des pêches (pour tous les lacs). L'observation des résultats de ces manipulations a permis de cerner certaines limitations désormais évidentes (notamment la taille du lac, sa concentration en nutriments inorganiques, les variations du recrutement d'alevins) quant à l'utilisation de la capacité du lac par les alevins de saumon rouge pour atteindre la production maximale de saumoneaux. D'importantes différences de ce paramètre de rendement clé persistent cependant entre les lacs, même après que les limites susmentionnées ont été prises en compte. Les recherches menées ailleurs donnent à penser que les différences subtiles dans la climatologie, le flux saisonnier de nutriments et la structure du réseau trophique des trois lacs peuvent induire des différences notables et persistantes dans leur capacité à produire des saumons rouges juvéniles. Le présent rapport documente en détail les méthodes et les ensembles de données associés à plusieurs années de travail (2008-2013), conçus pour comparer les divers éléments que sont la structure physique, l'état des nutriments et la structure du réseau trophique des lacs de séjour du saumon rouge de la baie Barkley. Les données résumées dans le présent rapport feront l'objet d'une analyse plus poussée pour approfondir notre connaissance des causes et de l'ampleur des différences de capacité biotique entre les lacs pour les saumons rouges juvéniles.

# PREFACE

Sockeye salmon conservation units (CUs) originating from three nursery lakes on the west coast of Vancouver Island support important First Nations, recreational and commercial fisheries in Barkley Sound. Consequently, these CUs have been a focus of stock development, fisheries management, research, and enhancement activities for more than a century (reviewed in Hyatt and Steer 1987). Although much has been learned about factors controlling production of Barkley Sound sockeye salmon, much remains to be learned about processes that control annual variations as well as the long-term, average production of juvenile and adult life history stages in freshwater and marine environments respectively. Fry and smolt production variations originating in freshwater were of particular interest here due to relatively recent changes in CU and lake-habitat management practices including: (a) abandonment of fixed escapement objectives and adoption of sliding exploitation rate rules controlling sockeye harvest after 1993, (b) absence of lake fertilization at Henderson Lake outside of treatment years 1976-1997, 1999 and 2007, and (c) changes of equipment (i.e. a new boat and spray-boom system) and procedures (i.e. weekly applications in the top 2/3rds of Great Central) used by Robertson Creek Hatchery staff for addition of annual inorganic fertilizer treatments to Great Central Lake.

Adoption of a sliding exploitation rate principle for sockeye harvest was associated with increased variability in annual escapements to Great Central and Sproat Lake where <70,000 adults spawned in either lake in 2008 followed in 2011 by escapement levels exceeding previous maxima for each lake by more than 100,000 spawners (i.e. 431,000 at Great Central and 382,000 at Sproat). Record escapements in 2011 raised concerns from industry about whether sockeye fry production (in summer 2012) or smolt production (in spring 2013) might decline due to excessive cropping of the zooplankton forage base in Great Central or Sproat lakes. Concerns at Henderson Lake focused on whether observations of reductions in smolt size and abundance outside of various annual lake fertilization treatment intervals (e.g. post 2007 to present), might signify a need to reduce adult escapement objectives and associated fry recruitment to balance the latter with reduced production of their zooplankton forage base. By contrast, concerns of Robertson Creek Hatchery staff revolved around whether there had been any detectable change in the effect of altered procedures for application of inorganic nutrient treatments at Great Central Lake on annual sockeye fry and smolt production relative to past years.

Comparative assessments of physical, chemical and food-web structure of the Barkley nursery lakes during the 2008-2013 were designed to provide observations to address questions regarding potential changes in the capacity of the lakes to produce sockeye salmon smolts given the relatively recent changes in management practices noted above.

# INTRODUCTION

The carrying capacity of sockeye salmon "nursery" lakes has been operationally defined as the point at which the maximum sustainable number and biomass of smolts are produced (Shortreed et al. 2000). The latter information is important in salmon management because it may be used as a basis for identifying associated optimum escapement and spring fry, recruitment requirements in a given lake. Two empirical models, the Euphotic Volume Model (EVM, Koenings and Burkett 1987) and the Photosynthetic Rate Model (PRM, Hume et al.

1996), have been widely applied to estimate the carrying capacity of "nursery" lakes in Alaska and British Columbia to support production of sockeye salmon fry and smolts.
The Euphotic Volume Model (Koenings and Burkett 1987) was based on lake fertilization manipulations in 13 Alaskan Lakes (Kyle et al. 1997). The objective was to develop an "empirical classification of sockeye salmon smolt production based upon the population characteristics of density, freshwater age, and mean size". From the Alaskan data, Koenings and Burkett (1987) developed a simple empirical model (EV Model) based on the volume of a lake capable of photosynthesis. They found that euphotic zone depths were positively (r=0.9) correlated with areal primary production rates and euphotic zone depth could be used as an index of primary production in Alaskan lakes. One EV unit was defined to equal 1,000,000 $m^3$ of water receiving sufficient irradiance to support photosynthesis and this was used to predict lake-specific optima for smolt numbers (23,000 smolts per EV unit), smolt biomasses, and adult escapement (2,500 adults per EV unit). However, when the EV model was applied to British Columbia lakes, the predictive capacity was judged to be poor (Hume et al. 1996).

The Photosynthetic Rate Model (PR Model, Hume et al. 1996) was developed to remedy problems encountered in applying the EV Model to BC nursery lakes and was based on a correlation between photosynthetic rate expressed as metric tons of carbon per year and associated maximum production of sockeye smolt biomass (Shortreed et al. 2000). The empirically-based PR Model has emerged as a promising tool to establish first order approximations of logarithmic-scale, carrying-capacity differences for juvenile sockeye among lakes exhibiting PRs varying by more than an order of magnitude. However, Shortreed et al. (2000) noted several assumptions that potentially limit its utility and recommended testing its applicability in a wider range of lakes. PR Model predictions of carrying capacities of three nursery lakes (Great Central, Sproat, Henderson) on the west coast of Vancouver Island appeared to be at odds with long-term observations of maximum biomass of sockeye smolts originating from these lakes. Research conducted elsewhere (McQueen et al 2007, Hyatt et al 2011) suggests that subtle differences in climatology, seasonal nutrient flux and food-web structure between lakes, and within lakes, between years, may induce large, persistent differences in the efficiency of energy transfer between trophic levels and the resultant capacity of lakes to produce juvenile sockeye. Thus, the objective of the 2008-13 Great Central (GCL), Sproat, and Henderson lakes sampling program was to expand our understanding of the importance of fry recruitment variations and food web structure and function as determinants of the carrying capacity of selected nursery lakes for sockeye salmon *Oncorhynchus nerka*. Multiyear observations from the current report are anticipated for use in future bioenergetics modelling, following methods laid out in a companion report (Hyatt et al., 2016), to quantify the carrying capacity of each of the three Barkley Sound nursery lakes to support their respective pelagic fish populations.

## STUDY AREA AND SITE DESCRIPTION

Great Central and Sproat lakes lie within the western area of the Somass Watershed that drains an area of about 1,426 $km^2$ into Alberni Inlet, a 54.3 x 1.5 km coastal fjord on southwestern Vancouver Island (Morris and Leaney 1981; Figure 1). The Somass Watershed consists of three major sub-basins: the Sproat system (387.5 $km^2$ in area), dominated by Sproat Lake, which drains into the Sproat River (mean daily flow 37.9 $m^3/s$); the Great Central Lake system (651 $km^2$), which drains into the Stamp River (mean daily flow 58.9 $m^3/s$); and the Ash system (388 $km^2$), draining Oshinow and Elsie lakes (mean daily flow 16.7 $m^3/s$) into the Stamp, which flows

15 km into the Somass River (Manzer, Morley, and Girodat 1985). The Somass River (mean daily flow rate of 121.4 $m^3/s$) runs for 8 km to its mouth at the head of Alberni Inlet. The Henderson Lake Watershed (49°06'N, 125°03'W) is located further to the west closer to Barkley Sound, approximately 25 km southwest of Port Alberni (Figure 1). Its' principal tributary is Clemens Creek that enters at the head end of Henderson Lake (Tschaplinski and Hyatt 1990) which drains an area of 135 $km^2$ into Barkley Sound via the Henderson River, Uchucklesit Inlet, and Alberni Inlet. Annual discharges in Clemens Creek and the Henderson River are ungauged.

The watersheds that contain Great Central, Sproat, and Henderson lakes experience a marine west coast climate, designated *Cfb* in the Koppen classification system (Peel, Finlayson, and McMahon, 2007), characterized by mild winters, warm summers, no dry season, and long spring and autumn seasons with small seasonal ranges in temperature. The climate is distinguished by several factors: the mean temperature ranges between 0°C and 22°C; and even the driest month of the year receives more than 30 mm of precipitation on average. In general, the climate in the northeastern Pacific also undergoes multi-decadal changes that affect climate variables such as air temperature and precipitation that fluctuate with the *Pacific Decadal Oscillation* index[1] (Hare & Mantua 2000) in these watersheds. Altitude and distance from the ocean also affect regional temperature patterns. Maximum temperatures are generally higher and minimum temperatures generally lower at inland weather stations and at higher elevations, such as at the Robertson Creek station closest to Great Central and Sproat lakes, relative to the more coastal weather station at Bamfield, which is closer to Henderson Lake. Although discharge from the Henderson Watershed remains ungauged, it is known to be influenced by high annual precipitation, almost exclusively in the form of rain, and has the distinction as the "wettest" place in North America, receiving an average of 6,655 mm of rainfall per year[2]. This represents more than twice the total annual precipitation at the Bamfield and Robertson Creek stations (Environment Canada, 2007).

Great Central (Figure 2), Sproat (Figures 3 and 4), and Henderson (Figure 5) lakes all serve as nursery lakes for juvenile sockeye salmon production that ultimately supports a valuable mixed stock fishery for sockeye salmon in Barkley Sound (Hyatt and Steer 1987). Given their geographic proximity, the three lakes exhibit sufficiently similar geology, climatology, hydrology, and nutrient dynamics to be classified as highly unproductive, oligotrophic, lakes typical of the British Columbia outer coast (Stockner and Shortreed 1985, Hyatt et al. 2004). Specific characteristics of each lake (Shortreed et al. 2002) are as follows: Great Central Lake (lat. 49°22' long. 125°15'lat., elevation 82 m), surface area 5100 ha, mean depth 212 m, water residence time 7.3 y, average total phosphorus TP = 2.6 $\mu g\ L^{-1}$); Sproat Lake (lat. 49°14' long. 125°06' lat., elevation 29 m, surface area 4100 ha, water residence time 8.0 y, mean depth 59 m, average TP = 2.7 $\mu g\ L^{-1}$) and Henderson Lake (lat. 49°05' long. 25°02'lat., elevation 5 m, surface area 1545 ha, mean depth 109 m, water residence time 5 y, average total phosphorus TP = <1 $\mu g\ L^{-1}$). All undergo one period of thermal stratification and one thermal mixing cycle each year (i.e. are monomictic), usually in the fall. Annual mixing of the entire volume of water is

[1] The Pacific Decadal Oscillation (PDO) is a pattern of Pacific climate variability that shifts phases on at least inter-decadal time scale, usually about 20 to 30 years. The PDO is detected as warm or cool surface waters in the Pacific Ocean, north of 20° N. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs (Hare a Mantua 2000).

[2] The Canadian record for precipitation in one year was 9,479 mm in 1997, followed by 8,123 mm at Henderson Lake, in 1931 (Environment Canada, 2007).

incomplete at Henderson Lake which remains permanently stratified (i.e. is meromictic) due to a saline layer below 45-50 m (Costella et al., 1980 as cited in Shortreed et al. 2001).

All three lakes have long histories of intentional manipulations (Hyatt and Steer 1987) including: introductions of hatchery-origin sockeye salmon fry (Henderson Lake 1910-1935 and 1994-2008), lake fertilization (at Great Central Lake 1970-1973, 1977-present; Henderson Lake 1976-1997, 1999, 2007; Sproat Lake 1985) and variable recruitment of sockeye fry associated with fluctuations in both adult returns and fisheries management objectives (all lakes, Dobson et al. 2005).

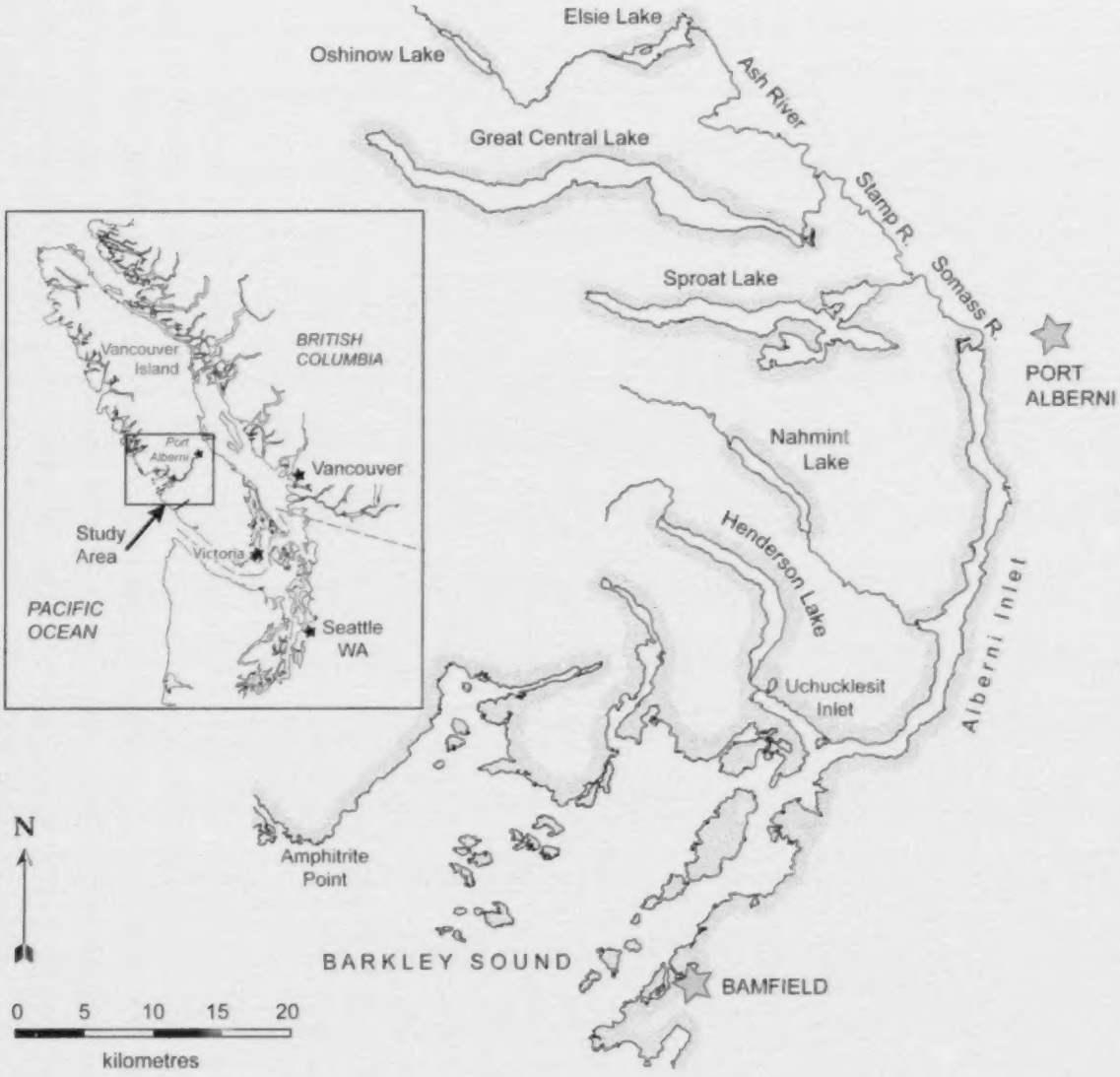



Figure 1. Location of Great Central, Sproat, and Henderson lakes on the west coast of Vancouver Island, B. C.

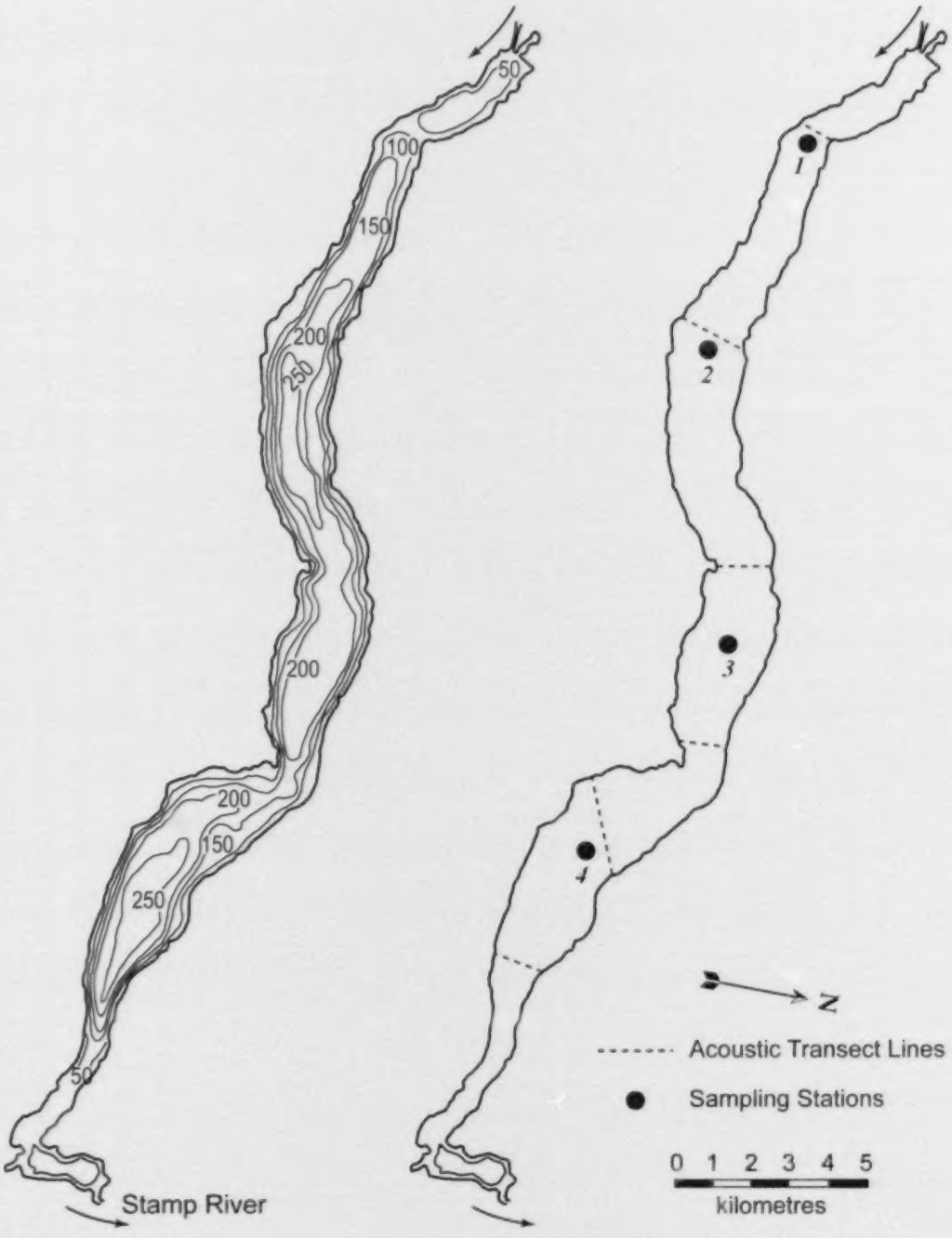



Figure 2. Great Central Lake (a) bathymetry contours (in metres) and (b) acoustic and trawl transect lines, and sampling stations. Zooplankton samples are collected at all stations except during 2008 when zooplankton were collected at stations 3 and 4; water chemistry and phytoplankton samples are collected from stations 3 and 4. Maps adapted from Rutherford et al. 1986.

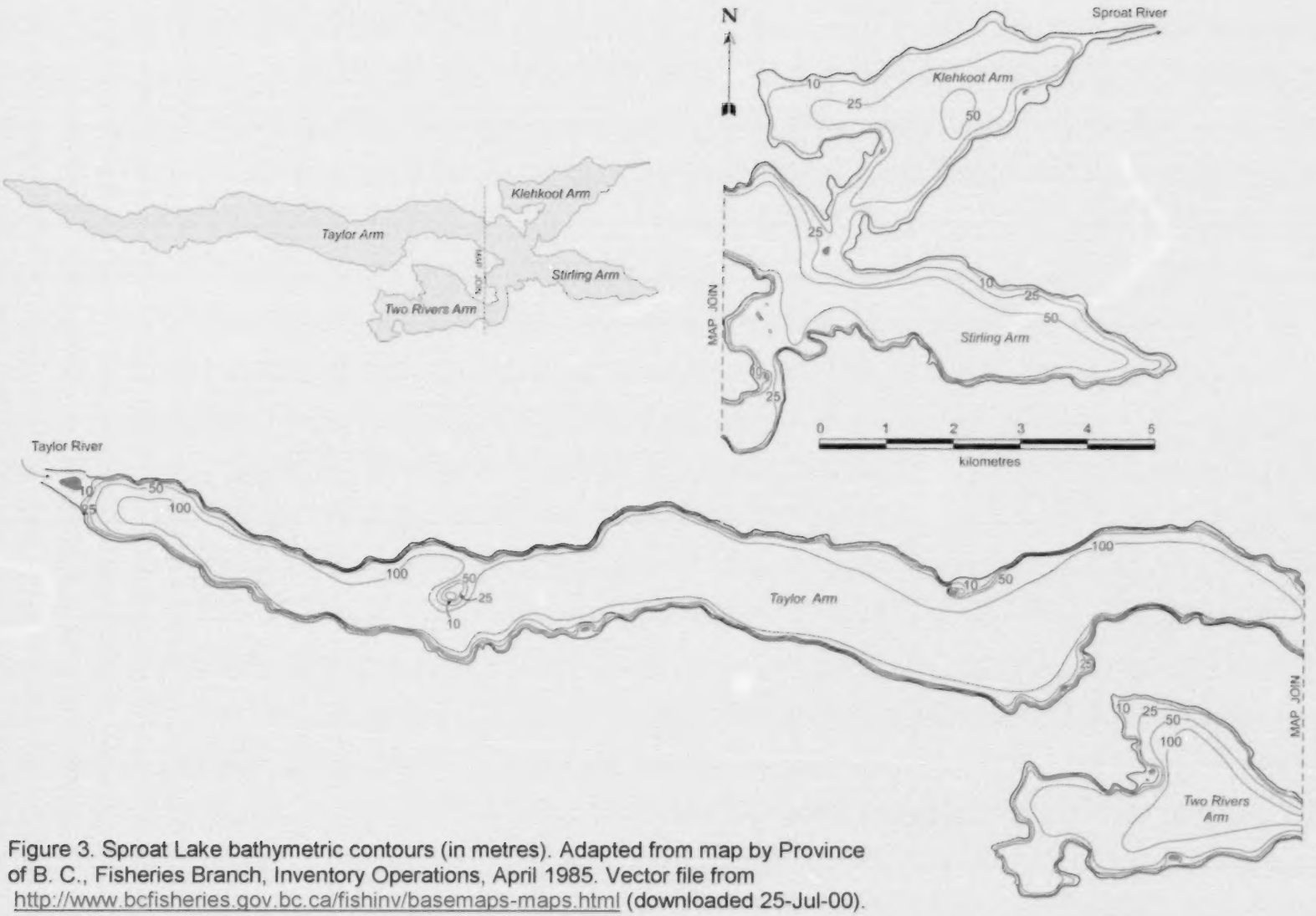



Figure 3. Sproat Lake bathymetric contours (in metres). Adapted from map by Province of B. C., Fisheries Branch, Inventory Operations, April 1985. Vector file from http://www.bcfisheries.gov.bc.ca/fishinv/basemaps-maps.html (downloaded 25-Jul-00).

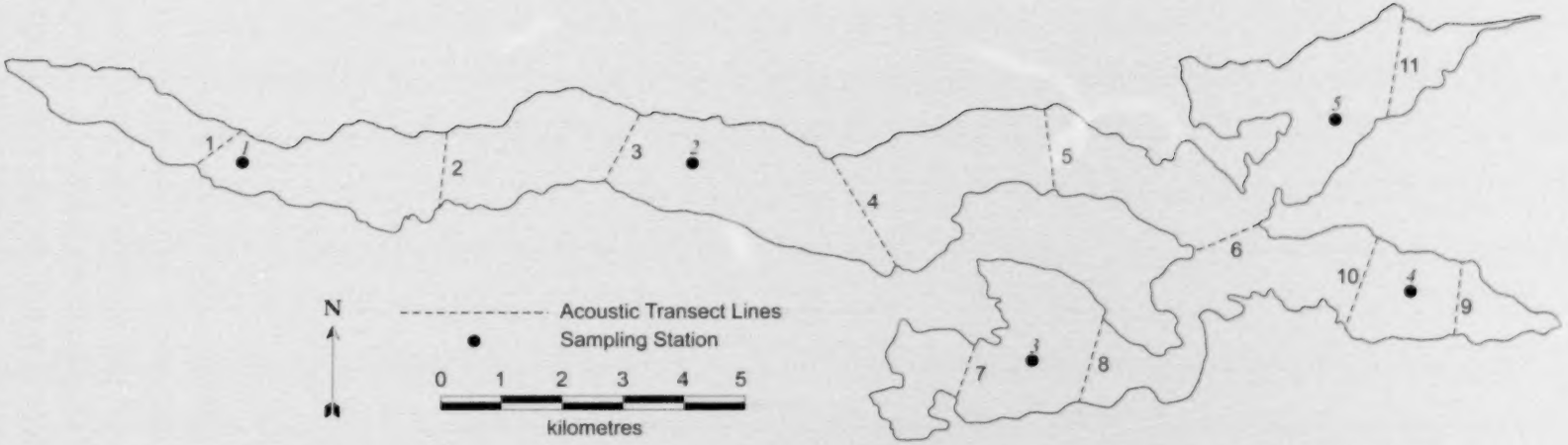



Figure 4. Sproat Lake acoustic and trawl transect lines, and sampling stations. Zooplankton samples are collected at all stations except during 2008 when zooplankton were collected at stations 2 and 3; water chemistry and phytoplankton samples are collected at stations 2 and 3.

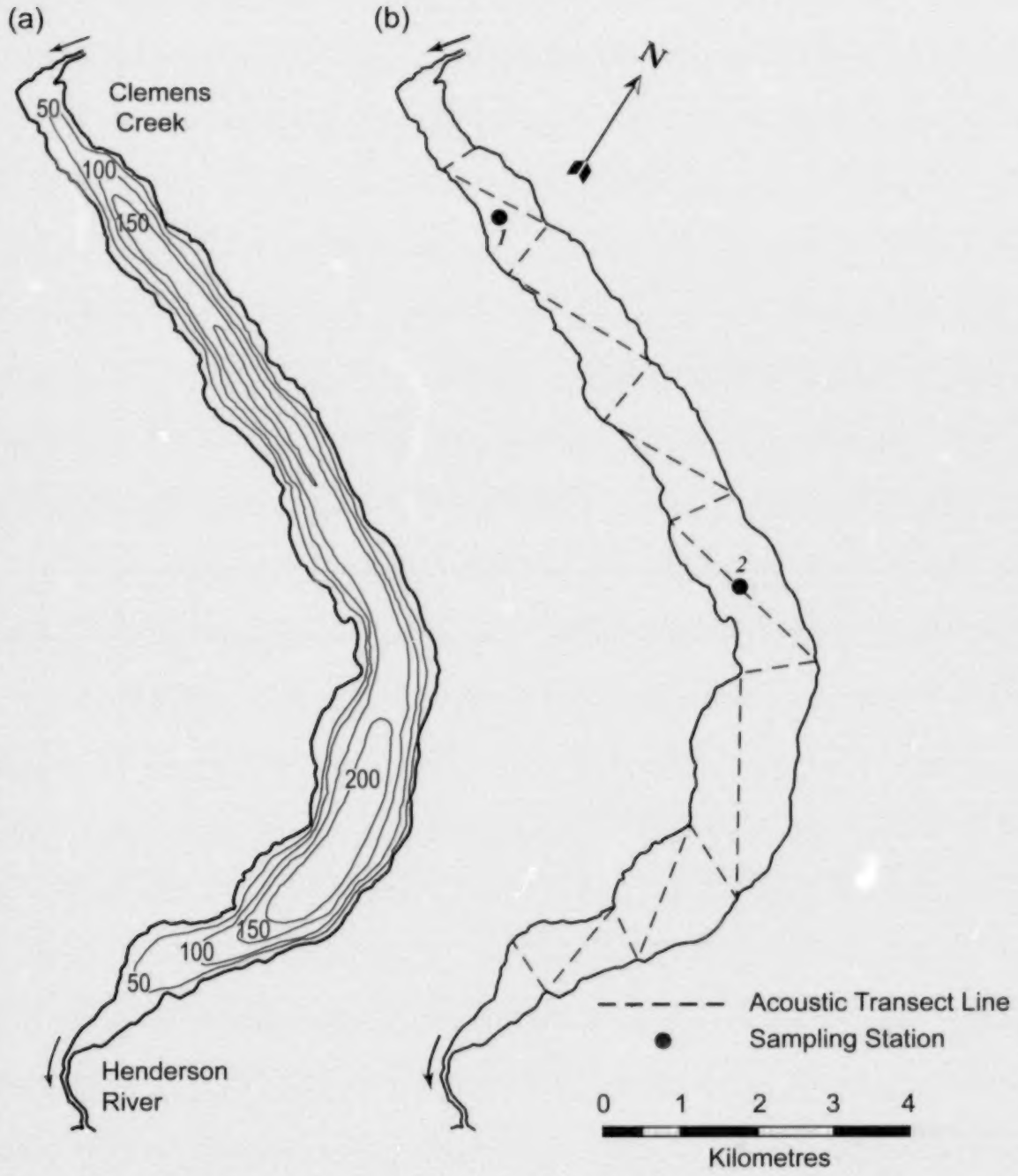



Figure 5. Henderson Lake (a) bathymetric contours (in metres) and (b) acoustic and trawl transect lines, and sampling stations (water, phytoplankton, and zooplankton). Maps are adapted from Rutherford et al. 1986.

# METHODS

## WATER CHEMISTRY

Limnological samples were collected at 1, 3, and 5 m (epilimnion) and 20 m (hypolimnion) at each of two stations on each lake (Great Central at stations 3 and 4; Sproat at stations 2 and 3; and Henderson at stations 1 and 2; Figures 2, 4 and 5). Total phosphorus (TP) samples were stored in screw-cap test tubes in the dark until analysis. $NO_3$, $NO_2$ samples were passed through an acrodisk filter, placed in screw-cap plastic bottles, and frozen until analysis. Chlorophyll a samples were filtered (47 mm Millipore) and frozen until analysis. Samples were analyzed at the Cultus Lake laboratory, Fisheries and Oceans Canada. Additional samples were sent to Vancouver Island University where they were analyzed for Na, Mg, and Ca (ppm) and for $CaCO_3$ alkalinity (ppm).

## PHYTOPLANKTON

Phytoplankton biomasses were recorded from samples taken from stations (identified above) at 1, 3, and 5m (combined) and at 25m. In some years, deep samples were intended to reveal sub-thermocline algal populations that were known from Sproat Lake but less certain from GCL and Henderson Lake. Densities, cell sizes, cell shapes, and biovolumes were recorded. One of the objectives of the phytoplankton counting procedure was to assess the relative availabilities of edible (grazable) and non-edible (non-grazable) algae. We quantified "edibility" based on size, toxicity, and digestibility. Single cells or colonies < 30 µm width or length were considered edible (Cyr 1998; Cottingham 1999) unless they were classified as being either "toxic" or "digestion-resistant" (defined below). *Microcystis* was always classified as being "toxic". Other genera were assumed non-toxic. Algae with thick gelatinous sheaths can pass through *Daphnia* guts undigested (Stutzman 1995) and were considered to be digestion-resistant, independent of size. Additional detail with respect to methods is available in Hyatt et al. (2005) and McQueen et al. (2007).

## ZOOPLANKTON

### VERTICAL HAULS

In GCL and Sproat lakes, zooplankton were sampled at stations 1 to 4 and 1 to 5, respectively (Figures 2 and 4); except during 2008 when zooplankton were collected at stations 3 and 4 in GCL and at stations 2 and 3 in Sproat Lake. Henderson Lake zooplankton were always collected at stations 1 and 2 (Figure 5). In all three lakes, zooplankton were sampled using a vertical haul net (100 µm mesh, 0.5 m net diameter, net length 3 m). Samples were collected every 3-6 weeks (see sample schedule for each year in the Results). Each sample was washed out of the plankton net using water saturated with carbon dioxide and were then preserved in 5.5% buffered and sugared formalin and returned to the laboratory.

Through 2008 - 2013, zooplankton collecting methods were modified (Table 1). During 2008 and 2009, the Rigosha meter was not used to correct for net clogging and changes in through-net flow. During 2010 - 2013, counts were corrected for net efficiency. During 2008, zooplankton samples were collected at night using the vertical haul net between 0-25m. During 2009 - 2010, samples were collected either at night over 25 m or during the day over 50 m, and in one case,

(Sproat Lake June 9, 2009) samples were collected both at night over 25m and during the day over 50m. During 2011 - 2013, samples were collected only during the day over 50 m.
In the laboratory, during 2008 - 2011, individual samples collected at each station were fully processed and the individual station counts were averaged to produce sample averages for each lake-date. During 2012 - 2013, individual lake-date samples were combined to produce one volume-weighted "combined" sample for each lake for each sampling date (McQueen et al. 2007). Because each of the samples had different sampling efficiencies (measured with a Rigosha flow meter), each station sample was suspended in water so that each one mL of sample contained water from 10 L of lake water. For each station, 10 mL (containing plankton from 100 L of lake water) from each sample jar was then added to a "combined" sample jar. Since there were 4 stations in GCL and 5 stations in Sproat Lake, the combined GCL sample jar contained 40 mL of sample representing the zooplankton found in 400 L of lake water and the combined Sproat Lake sample jar contained 50 mL of sample representing the zooplankton found in 500 L of lake water. Since there were 2 stations in Henderson Lake, the combined sample jar contained 20 mL of sample representing the zooplankton found in 200 L of lake water. The original samples were then re-filtered to remove excess water, re-suspended in 5.5 % formalin and relabelled to record the loss of a certain percentage of the sample.

During 2008 - 2011, Cladocera and copepods (adults and copepodids) were identified to species. Nauplii were identified as either *Diacyclops thomasi* or *Leptodiaptomus ashlandi*. Edmondson (1959) was the principal taxonomic reference. To calculate biomass, body lengths of all animals were measured using a semi-automated counting and measuring system and individual biomasses were calculated using length - wet weight regressions (Rankin, DFO, pers. comm.).

During 2012 - 2013 Cladocera and copepods (adults and copepodids) were identified to species. Nauplii were identified as either *Diacyclops thomasi* or *Leptodiaptomus ashlandi*. Edmondson (1959) was the principal taxonomic reference, but also Dussart and Fernando (1990) for Cyclopoida, Korinek (1981) for *Diaphanosoma*, and Lieder (1983) for bosminids. Eggs per female were counted for all species. To calculate biomass, body lengths of all animals were measured using a semi-automated counting and measuring system (Allen et al. 1994). Animal weights were estimated using length-weight regressions summarized in Girard and Reid (1990). If preserved animals were used to develop these regressions, a 39% correction for weight loss in formalin was applied (Giguère et al. 1989). Additional detail for these methods is provided in Yan et al. (2001). During 2008 - 2013, preserved lengths for *Holopedium gibberum* were not corrected for contraction due to preservative (Yan and Mackie 1987, Campbell and Chow-Fraser 1995).

Table 1. Summary of changes in zooplankton sampling methods used in Great Central, Sproat, and Henderson lakes during 2008 - 2013. D50 = day sampling at depth 0-50m, N25 = night sampling at depth 0-25m. Rigosha = metered hauls; no = no Rigosha meter used. Abbreviations ww and dw = wet and dry weights.

| | Year | Day 50 m or night 25 m | Rigosha meter | ww counts or dw counts | Number sampling dates |
|---|---|---|---|---|---|
| Great Central Lake | 2008 | N25 | no | ww | 6 |
| | 2009 | D50, N25 | no | ww | 6 |
| | 2010 | D50, N25 | Rigosha | ww | 3 |
| | 2011 | D50 | Rigosha | ww | 4 |
| | 2012 | D50 | Rigosha | dw | 5 |
| | 2013 | D50 | Rigosha | dw | 7 |
| Sproat Lake | 2008 | N25 | no | ww | 4 |
| | 2009 | D50, N25 | no | ww | 6 |
| | 2010 | D50, N25 | Rigosha | ww | 3 |
| | 2011 | D50 | Rigosha | ww | 4 |
| | 2012 | D50 | Rigosha | dw | 4 |
| | 2013 | D50 | Rigosha | dw | 7 |
| Henderson Lake | 2008 | N25 | no | ww | 7 |
| | 2009 | D50, N25 | no | ww | 3 |
| | 2010 | D50, N25 | Rigosha | ww | 4 |
| | 2011 | D50 | Rigosha | ww | 4 |
| | 2012 | D50 | Rigosha | dw | 3 |
| | 2013 | D50 | Rigosha | dw | 6 |

In the tables and figures that follow in the results section, zooplankton biomasses are shown as µg per L dry weight. However, during 2008 - 2011 wet weight length-weight regressions were used for the actual counts and dry weights were calculated as wet weight divided by seven. This is based on dry:wet mass ratios that vary from 11-14% for copepods and 10-12 % for cladocerans (Downing and Rigler 1984). We switched to dry weight regressions because they are now in common use and have been based on more data than the older wet weight regressions. It should be noted that the 2008 - 2011 data are also subject to larger errors caused by different slopes in the length – wet weight regressions. To learn more about these errors, we counted the same samples using both wet and dry regressions. We then investigated mass differences for various species over the size range found in GCL and Sproat Lakes. We found that for *Daphnia*, the wet weight regression overestimated mass by about 30% when compared to the dry weight regression. This was also the case for copepods. However, for *Bosmina*, the situation was more complicated. Two ww regressions were used. During 2009, 2010, and 2011, the laboratory used the ww regression for *Bosmina longirostris* (code number 101) which underestimated *Bosmina* mass by a factor of four. During 2008, the laboratory used

the regression for *Bosmina longispina* (code number 100) which overestimated mass by a factor of two. Both of these trends are easily detected in the results table and figure.

Although it is tempting to use these comparative data to "correct" the biomasses in the accompanying table and figure, we have not done so. Since we have not attempted to compare results between years, we chose to err on the side of caution, explain the issues regarding sampling errors, and leave the data in their original form. However, if these data are used in between year comparisons in future, it is likely that corrected biomass data will yield total biomasses exhibiting greater year to year consistency (annual bar heights would be more similar).

### ZOOPLANKTON SCHINDLER TRAP SAMPLING

On 09 Sept, 2009, we sampled zooplankton from Great Central and Sproat lakes during the day from 13:00-16:00 and again after dark (21:00-24:00) using a 30 L Schindler-Patalas trap equipped with a 100 µm net. Day versus night samples were obtained with the same gear in June of 2010. Day versus night trap-samples were also taken from Henderson Lake in June of 2010. The trap was deployed every 2 meters from 0-40 m water depth. In the laboratory, samples were split and species-specific densities were estimated.

## SOCKEYE SALMON AND STICKLEBACK SAMPLING

Juvenile sockeye salmon (*Oncorhynchus nerka*) abundance in Great Central and Sproat lakes and juvenile sockeye salmon and stickleback (*Gasterosteus aculeatus*) abundance in Henderson Lake, were assessed 2-4 times per year (depending on the lake-year; sample schedules in the results) using a Biosonics DT-X echosounder (200 kHz sounder, pulse width at 0.4 ms and a 6.6° transducer). Surveys during spring through fall (June-Oct) were executed to determine peak fry abundance and diet composition during the active growing season. Winter surveys (Nov-Feb) were executed to determine end of growing season fry size and abundance estimates where the latter are considered to be a useful estimate of annual smolt production (Hyatt et al, 2015).

A standardized trip report was produced for each survey regarding weather conditions, gear conditions, survey execution and anomalous conditions (i.e. metadata) that might influence the quality of the subsequent observational data. More details on general survey methods and post-survey data processing are available in MacLellan and Hume (2010). The acoustics transducer was towed at night over 6 transects in GCL (Figure 2), 11 transects in Sproat Lake (Figure 4), and 15 transects in Henderson Lake (Figures 5). During each sampling trip, samples of pelagic fish were collected using a 3m x 7m mid-water trawl designed by Gjernes (1979) and modified by Enzenhofer and Hume (1989). Captured fish were preserved in 95% ethanol. Fish samples were transported to the laboratory, where the preservative was changed twice over six weeks. They were then removed from the preservative, blotted dry, measured (total length), and weighed. Weights were corrected for the effects of ethanol using the expression (fresh weight = preserved weight/0.868429; P. Rankin, Pacific Biological Station, unpublished data).

# RESULTS

## YEAR 2008: GREAT CENTRAL, SPROAT, AND HENDERSON LAKES DATA SUMMARY

SAMPLING SCHEDULE FOR 2008

Table 2. Samples collected during 2008. N-25 means sampled at night 0-25 m, x = data available, 0 = data unavailable, and nd = data not part of the sampling scheme. TR = trip report regarding sample types taken and survey conditions is available. GCL fertilization schedule is available in Appendix 1, Table 1.

| Survey Date | DFO chemistry | VIU chemistry | Temperature | Oxygen | Secchi | Phytoplankton 1,3,5 | Zooplankton | Rigosha | Acoustic Records | Fish Biosamples | Smolts (2009) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2008** | | | | | | | | | | | | |
| 5-May-08 | x | nd | x | | x | x | N-25 | x | | | | TR |
| 9-Jun-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 17-Jul-08 | x | nd | x | 0 | x | x | N-25 | 0 | x | x | | TR |
| 20-Aug-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 17-Sep-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 23-Oct-05 | x | nd | | | x | x | N-25 | 0 | | | | TR |
| 17-Nov-08 | | | | | | | | | x | | | TR |
| 04-Feb-09 | | | | | | | | | x | | | TR |
| 17-Nov-08 | | | | | | | | | x | | | TR |
| 18 April-15 May-09 | | | | | | | | | | | x | |
| **Sproat 2008** | | | | | | | | | | | | |
| 5-May-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 22-Jul-08 | x | nd | x | 0 | x | x | N-25 | 0 | x | x | | TR |
| 15-Sep-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 16-Oct-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 1-Dec-08 | | | | | | | | | x | | | TR |
| 15 April-5 May-09 | | | | | | | | | | | x | |
| **Henderson 2008** | | | | | | | | | | | | |
| 12-May-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 26-May-08 | | | | | | | N-25 | 0 | | x | | TR |
| 18-Jun-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 15-Jul-08 | x | nd | x | 0 | x | x | N-25 | 0 | x | x | | TR |
| 21-Aug-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 24-Sep-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 15-Oct-08 | x | nd | x | 0 | x | x | N-25 | 0 | | | | TR |
| 18-Nov-08 | | | | | | | | | x | x | | TR |
| 29-Jan-09 | | | | | | | | | x | x | | TR |
| 16-April-09 | | | | | | | | | | | x | |

TEMPERATURES AND SECCHI DEPTHS: Results from Great Central and Sproat lakes were similar. Henderson had colder spring temperatures and water that was more turbid. Both of these characteristics would be expected to reduce productive capacity for juvenile sockeye salmon.

Table 3. Year 2008 water temperatures and Secchi depths.

**(a) Great Central Lake 2008**

| Depth (m) | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 5-May | 9-Jun | 17-Jul | 20-Aug | 17-Sep | 23-Oct |
| 0 | 11.0 | 13.3 | 21.0 | 19.8 | 20.2 | 13.0 |
| 2 | 10.1 | 13.4 | 20.9 | 19.9 | 20.0 | |
| 4 | 9.6 | 13.4 | 20.1 | 19.8 | 19.7 | |
| 6 | 9.0 | 13.2 | 19.0 | 19.6 | 19.1 | |
| 8 | 8.4 | 10.7 | 15.3 | 18.5 | 18.0 | |
| 10 | 8.0 | 9.0 | 13.1 | 16.8 | 16.3 | |
| 12 | 7.4 | 8.3 | 12.1 | 14.3 | 12.9 | |
| 14 | 7.1 | 7.3 | 10.3 | 10.7 | 10.1 | |
| 16 | 6.8 | 6.7 | 8.9 | 9.1 | 8.4 | |
| 18 | 6.5 | 6.0 | 8.1 | 7.7 | 7.1 | |
| 20 | 6.4 | 5.7 | 7.3 | 6.9 | 6.4 | |
| 22 | 6.1 | 5.4 | 6.7 | 6.6 | 6.0 | |
| Secchi Depth (m) | 10.6 | 4.9 | 9.0 | 11.1 | 7.4 | 10.4 |

**(b) Sproat Lake 2008**

| Depth (m) | Temperature (°C) | | | |
|---|---|---|---|---|
| | 5-May | 22-Jul | 15-Sep | 16-Oct |
| 0 | 11.1 | 20.9 | 21.1 | 14.4 |
| 2 | 10.4 | 20.9 | 20.4 | 14.5 |
| 4 | 9.7 | 20.8 | 20.0 | 14.5 |
| 6 | 9.2 | 20.7 | 19.7 | 14.5 |
| 8 | 8.5 | 19.9 | 18.5 | 14.5 |
| 10 | 8.0 | 18.5 | 17.0 | 14.5 |
| 12 | 7.7 | 14.6 | 14.5 | 14.7 |
| 14 | 7.4 | 13.1 | 11.7 | 11.5 |
| 16 | 6.9 | 12.9 | 9.8 | 10.0 |
| 18 | 6.5 | 13.1 | 8.7 | 8.8 |
| 20 | 6.3 | 13.0 | 7.9 | 7.8 |
| 22 | 5.9 | 12.2 | 7.4 | 7.4 |
| Secchi Depth (m) | 8.9 | 5.7 | 12.2 | 12.9 |

**(c) Henderson Lake 2008**

| Depth (m) | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 12-May | 18-Jun | 15-Jul | 21-Aug | 24-Sep | 15-Oct |
| 0 | 9.9 | 13.0 | 18.4 | 19.1 | 17.4 | 13.7 |
| 2 | 9.7 | 12.9 | 18.5 | 19.1 | 17.5 | 13.8 |
| 4 | 9.6 | 12.9 | 18.4 | 19.1 | 17.5 | 13.8 |
| 6 | 9.4 | 12.9 | 18.4 | 19.0 | 17.4 | 13.8 |
| 8 | 9.3 | 13.0 | 18.1 | 19.0 | 17.2 | 13.8 |
| 10 | 9.2 | 12.9 | 18.3 | 18.9 | 17.0 | 13.8 |
| 12 | 9.1 | 12.8 | 18.2 | 18.7 | 16.2 | 13.8 |
| 14 | 8.5 | 12.7 | 16.6 | 16.7 | 15.3 | 13.8 |
| 16 | 8.1 | 12.3 | 15.2 | 13.3 | 13.8 | 13.7 |
| 18 | 7.5 | 9.9 | 14.6 | 10.1 | 12.4 | 12.6 |
| 20 | 7.1 | 8.4 | 11.9 | 7.9 | 9.3 | 11.2 |
| 22 | 6.9 | 7.4 | 10.5 | 7.2 | 8.1 | 9.4 |
| **Secchi Depth (m)** | 6.9 | 7.3 | 5.6 | 7.7 | 7.6 | 6.5 |

WATER CHEMISTRY: Estimates for TP were much higher in GCL and Sproat Lake than they were in Henderson Lake. Surprisingly the opposite was true for Chlorophyll, which was higher in Henderson Lake.

Table 4. Year 2008 water chemistry averaged over 2 stations in each lake.

**(a) Great Central Lake 2008**

| Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| 5-May-08 | 1, 3, 5 | 43.3 | 1.8 | 0.270 | 20 | 46.4 | 1.8 |
| 9-Jun-08 | 1, 3, 5 | 19.5 | 4.2 | 1.395 | 20 | 44.7 | 3.4 |
| 17-Jul-08 | 1, 3, 5 | 2.1 | 4.9 | 0.231 | 20 | 35.9 | 3.6 |
| 20-Aug-08 | 1, 3, 5 | | 1.6 | 0.578 | 20 | | 1.4 |
| 17-Sep-08 | 1, 3, 5 | | 2.4 | 0.929 | 20 | | 2.0 |
| 23-Oct-08 | 1, 3, 5 | | 1.2 | 0.970 | 20 | | 1.2 |

**(b) Sproat Lake 2008**

| Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| 5-May-08 | 1, 3, 5 | 20.1 | 2.6 | 0.274 | 20 | 29.7 | 2.5 |
| 22-Jul-08 | 1, 3, 5 | 2.9 | 4.9 | 0.134 | 20 | 6.2 | 4.5 |
| 15-Sep-08 | 1, 3, 5 | | 1.7 | 0.161 | 20 | | 2.4 |
| 16-Oct-08 | 1, 3, 5 | | 1.6 | 0.561 | 20 | | 1.4 |

**(c) Henderson Lake 2008**

| Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| 12-May-08 | 1, 3, 5 | 27.4 | 0.9 | 0.822 | 20 | 36.1 | <0.1 |
| 18-Jun-08 | 1, 3, 5 | 35.0 | <0.1 | 0.358 | 20 | 26.9 | <0.1 |
| 16-Jul-08 | 1, 3, 5 | 15.1 | <0.1 | 0.848 | 20 | 31.9 | <0.1 |
| 21-Aug-08 | 1, 3, 5 | | <0.1 | 0.866 | 20 | | <0.1 |
| 24-Sep-08 | 1, 3, 5 | | <0.1 | 0.773 | 20 | | <0.1 |
| 15-Oct-08 | 1, 3, 5 | | <0.1 | 1.012 | 20 | | <0.1 |

PHYTOPLANKTON BIOMASSES: Biomass was highest in GCL, but most of that comprised *Rhizosolenia* (Bacillariophyta), a large glass-like diatom that cannot be consumed by zooplankton. Henderson Lake had the highest biomasses of edible algae, dominated by Chrysophytes.

Table 5. Year 2008 total and edible phytoplankton biovolume. Values are expressed as $mm^3$ / $m^3$.

**(a) Great Central Lake 2008 (see Figure 6a)**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 05-May | 1,3,5 | 0 | 33 | 9 | 0 | 32 | 3 | 1 | 5 | 0 | 267 | 351 |
| 09-Jun | 1,3,5 | 0 | 56 | 19 | 0 | 67 | 5 | 1 | 26 | 0 | 3397 | 3572 |
| 17-Jul | 1,3,5 | 0 | 18 | 8 | 0 | 17 | 1 | 12 | 8 | 0 | 242 | 307 |
| 20-Aug | 1,3,5 | 0 | 51 | 2 | 0 | 372 | 0 | 4 | 31 | 0 | 92 | 552 |
| 17-Sep | 1,3,5 | 0 | 31 | 2 | 0 | 711 | 3 | 2 | 8 | 0 | 99 | 857 |
| 23-Oct | 1,3,5 | 0 | 22 | 8 | 0 | 263 | 6 | 2 | 10 | 0 | 35 | 346 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 05-May | 1,3,5 | 0 | 33 | 9 | 0 | 31 | 3 | 1 | 4 | 0 | 18 | 100 |
| 09-Jun | 1,3,5 | 0 | 30 | 19 | 0 | 54 | 5 | 1 | 24 | 0 | 26 | 159 |
| 17-Jul | 1,3,5 | 0 | 16 | 8 | 0 | 17 | 1 | 12 | 8 | 0 | 0 | 61 |
| 20-Aug | 1,3,5 | 0 | 40 | 2 | 0 | 17 | 0 | 4 | 30 | 0 | 13 | 106 |
| 17-Sep | 1,3,5 | 0 | 22 | 2 | 0 | 14 | 3 | 2 | 7 | 0 | 34 | 85 |
| 23-Oct | 1,3,5 | 0 | 6 | 8 | 0 | 9 | 6 | 2 | 9 | 0 | 1 | 40 |

(continued)

**(b) Sproat Lake 2008 (see Figure 6b)**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 05-May | 1,3,5 | 0 | 47 | 12 | 0 | 56 | 2 | 0 | 38 | 0 | 1382 | 1537 |
| 22-Jul | 1,3,5 | 1 | 15 | 0 | 0 | 14 | 0 | 2 | 8 | 0 | 78 | 118 |
| 15-Sep | 1,3,5 | 0 | 16 | 1 | 0 | 16 | 0 | 6 | 12 | 0 | 13 | 64 |
| 16-Oct | 1,3,5 | 0 | 51 | 7 | 0 | 29 | 0 | 8 | 4 | 0 | 10 | 109 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 05-May | 1,3,5 | 0 | 47 | 12 | 0 | 56 | 2 | 0 | 37 | 0 | 145 | 300 |
| 22-Jul | 1,3,5 | 0 | 5 | 0 | 0 | 14 | 0 | 2 | 8 | 0 | 28 | 57 |
| 15-Sep | 1,3,5 | 0 | 1 | 1 | 0 | 16 | 0 | 6 | 12 | 0 | 13 | 49 |
| 16-Oct | 1,3,5 | 0 | 51 | 7 | 0 | 29 | 0 | 8 | 4 | 0 | 10 | 109 |

**(c) Henderson Lake 2008 (see Figure 6c)**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 12-May | 1,3,5 | 1 | 159 | 7 | 0 | 459 | 14 | 1 | 7 | 0 | 75 | 722 |
| 18-Jun | 1,3,5 | 0 | 42 | 3 | 0 | 11 | 1 | 3 | 15 | 0 | 710 | 785 |
| 17-Jul | 1,3,5 | 0 | 63 | 6 | 0 | 47 | 6 | 11 | 12 | 0 | 240 | 385 |
| 21-Aug | 1,3,5 | 0 | 76 | 22 | 0 | 35 | 39 | 1 | 13 | 0 | 203 | 388 |
| 24-Sep | 1,3,5 | 0 | 10 | 3 | 0 | 70 | 13 | 1 | 13 | 0 | 50 | 160 |
| 15-Oct | 1,3,5 | 0 | 17 | 7 | 0 | 147 | 26 | 0 | 19 | 0 | 32 | 248 |
| **Edible Phytobiovolume** | | | | | | | | | | | 219 | 448 |
| 12-May | 1,3,5 | 0 | 159 | 7 | 0 | 458 | 14 | 1 | 6 | 0 | 1 | 647 |
| 18-Jun | 1,3,5 | 0 | 16 | 3 | 0 | 11 | 1 | 3 | 14 | 0 | 13 | 60 |
| 17-Jul | 1,3,5 | 0 | 10 | 6 | 0 | 47 | 6 | 11 | 12 | 0 | 3 | 95 |
| 21-Aug | 1,3,5 | 0 | 10 | 3 | 0 | 70 | 13 | 1 | 13 | 0 | 37 | 147 |
| 24-Sep | 1,3,5 | 0 | 10 | 3 | 0 | 70 | 13 | 1 | 13 | 0 | 32 | 141 |
| 15-Oct | 1,3,5 | 0 | 13 | 7 | 0 | 147 | 26 | 0 | 19 | 0 | 21 | 233 |

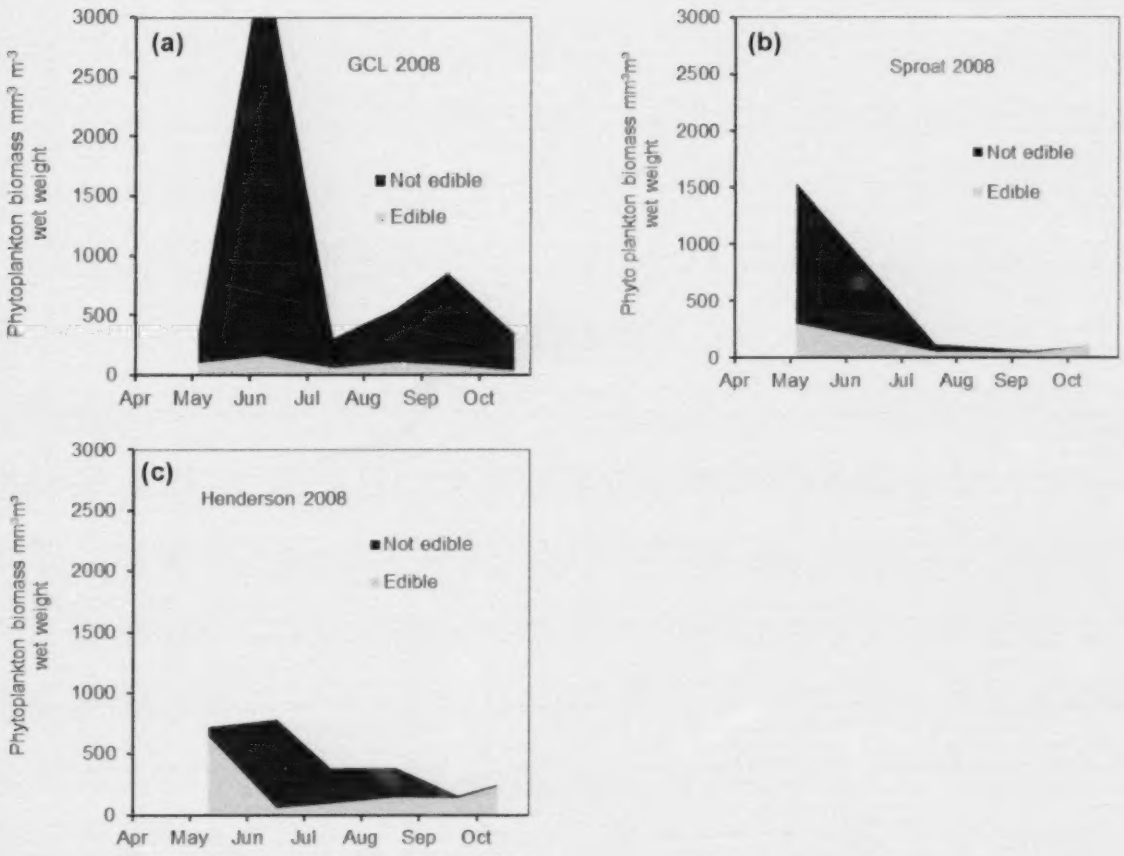



Figure 6. Year 2008 phytoplankton biomass as $mm^3\ m^{-3}$, which approximates $\mu g\ L^{-1}$ wet weight.

ZOOPLANKTON BIOMASSES: Biomasses were highest in Sproat > GCL > Henderson Lake. Species diversity was about equal in GCL and Sproat and much lower in Henderson Lake. Given that Henderson Lake edible phytoplankton biomasses were higher (Table 5, Figure 6) than they were in GCL and Sproat Lakes, it seems likely that zooplankton were limited by factors other than simple food availability. Perhaps low temperatures, higher water volume replacement rates and higher turbidity (Table 3) were implicated.

Table 6. Year 2008 zooplankton density per L and biomass as µg/L dry weight.

**(a) Great Central Lake 2008 (see Figure 7a)**

| Sampling Date | Nauplii | Cyclopoid adult & copepodids | Calanoid adult & copepodids | *Epischura* adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Diaphanosoma* | Chironomid larvae | Rotifers |
|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | |
| 05-May | 1.89 | 6.26 | 0.04 | 0.00 | 0.04 | 0.05 | 0.00 | 0.00 | 0.00 | 0.97 |
| 09-Jun | 0.18 | 1.76 | 0.03 | 0.01 | 0.26 | 0.02 | 0.01 | 0.00 | 0.00 | 0.83 |
| 17-Jul | 0.56 | 1.09 | 0.02 | 0.00 | 7.04 | 0.82 | 0.02 | 0.00 | 0.00 | 0.85 |
| 20-Aug | 0.22 | 0.67 | 0.15 | 0.00 | 1.90 | 0.15 | 0.02 | 0.00 | 0.00 | 0.13 |
| 17-Sep | 0.38 | 0.41 | 0.61 | 0.00 | 2.08 | 0.17 | 0.06 | 0.06 | 0.00 | 0.11 |
| 23-Oct | 1.09 | 0.29 | 0.18 | 0.00 | 2.66 | 0.13 | 0.16 | 0.07 | 0.00 | 0.48 |
| **Biomass per L** | | | | | | | | | | |
| 05-May | 0.33 | 11.40 | 0.38 | 0.01 | 0.11 | 0.08 | 0.01 | 0.00 | 0.01 | 0.03 |
| 09-Jun | 0.02 | 4.93 | 0.19 | 0.16 | 0.13 | 0.04 | 0.04 | 0.00 | 0.01 | 0.02 |
| 17-Jul | 0.06 | 3.36 | 0.22 | 0.04 | 11.04 | 1.92 | 0.11 | 0.00 | 0.04 | 0.01 |
| 20-Aug | 0.02 | 2.30 | 0.39 | 0.02 | 0.95 | 0.65 | 0.11 | 0.00 | 0.00 | 0.00 |
| 17-Sep | 0.05 | 1.43 | 2.52 | 0.02 | 1.71 | 0.82 | 0.26 | 0.15 | 0.00 | 0.00 |
| 23-Oct | 0.09 | 0.96 | 1.39 | 0.00 | 2.38 | 0.73 | 0.57 | 0.27 | 0.00 | 0.01 |

**(b) Sproat Lake 2008 (see Figure 7b)**

| Sampling Date | Nauplii | Cyclopoid adult & copepodids | Calanoid adult & copepodids | *Epischura* adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Diaphanosoma* | *Polyphemus* | Chironomid larvae | Rotifers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 05-May | 2.03 | 7.15 | 0.02 | 0.02 | 0.11 | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 | 0.15 |
| 22-Jul 8 | 0.35 | 1.56 | 0.00 | 0.00 | 1.31 | 0.29 | 0.65 | 0.00 | 0.00 | 0.00 | 2.08 |
| 15-Sep | 0.16 | 0.36 | 0.00 | 0.00 | 1.98 | 0.71 | 0.38 | 0.00 | 0.00 | 0.00 | 0.66 |
| 16-Oct | 0.84 | 0.18 | 0.04 | 0.01 | 3.33 | 0.21 | 0.35 | 0.00 | 0.01 | 0.00 | 1.08 |
| **Biomass per L** | | | | | | | | | | | |
| 05-May | 0.27 | 19.63 | 0.16 | 0.20 | 0.41 | 0.01 | 0.86 | 0.00 | 0.00 | 0.01 | 0.00 |
| 22-Jul | 0.05 | 6.20 | 0.00 | 0.02 | 3.37 | 0.74 | 2.30 | 0.00 | 0.00 | 0.00 | 0.03 |
| 15-Sep | 0.02 | 1.29 | 0.02 | 0.06 | 1.60 | 2.23 | 1.39 | 0.00 | 0.02 | 0.00 | 0.01 |
| 16-Oct | 0.08 | 0.62 | 0.25 | 0.11 | 2.88 | 0.81 | 1.27 | 0.00 | 0.03 | 0.00 | 0.02 |

**(c) Henderson Lake 2008 (see Figure 7c)**

| Sampling Date | *Bosmina* | Calanoid adult & copepodids | Cyclopoid adult & copepodids | *Epischura* adult & copepodids | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* |
|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | |
| 12-May | 0.23 | 0.04 | 0.09 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 26-May | 0.31 | 0.03 | 0.07 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 18-Jun | 0.74 | 0.16 | 0.07 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 16-Jul | 3.20 | 0.03 | 0.04 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 21-Aug | 2.98 | 0.08 | 0.16 | | 0.01 | 0.00 | 0.00 | 0.00 |
| 24-Sep | 1.65 | 0.04 | 0.07 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 15-Oct | 0.79 | 0.18 | 0.06 | | 0.00 | 0.00 | 0.00 | 0.00 |
| **Biomass per L** | | | | | | | | |
| 12-May | 0.38 | 0.40 | 0.30 | | 0.00 | 0.01 | 0.00 | 0.00 |
| 26-May | 0.47 | 0.23 | 0.22 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 18-Jun | 0.85 | 0.79 | 0.21 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 16-Jul | 3.31 | 0.13 | 0.12 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 21-Aug | 1.35 | 0.39 | 0.42 | | 0.02 | 0.00 | 0.00 | 0.00 |
| 24-Sep | 0.42 | 0.12 | 0.13 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 15-Oct | 0.21 | 1.26 | 0.14 | | 0.00 | 0.00 | 0.00 | 0.00 |

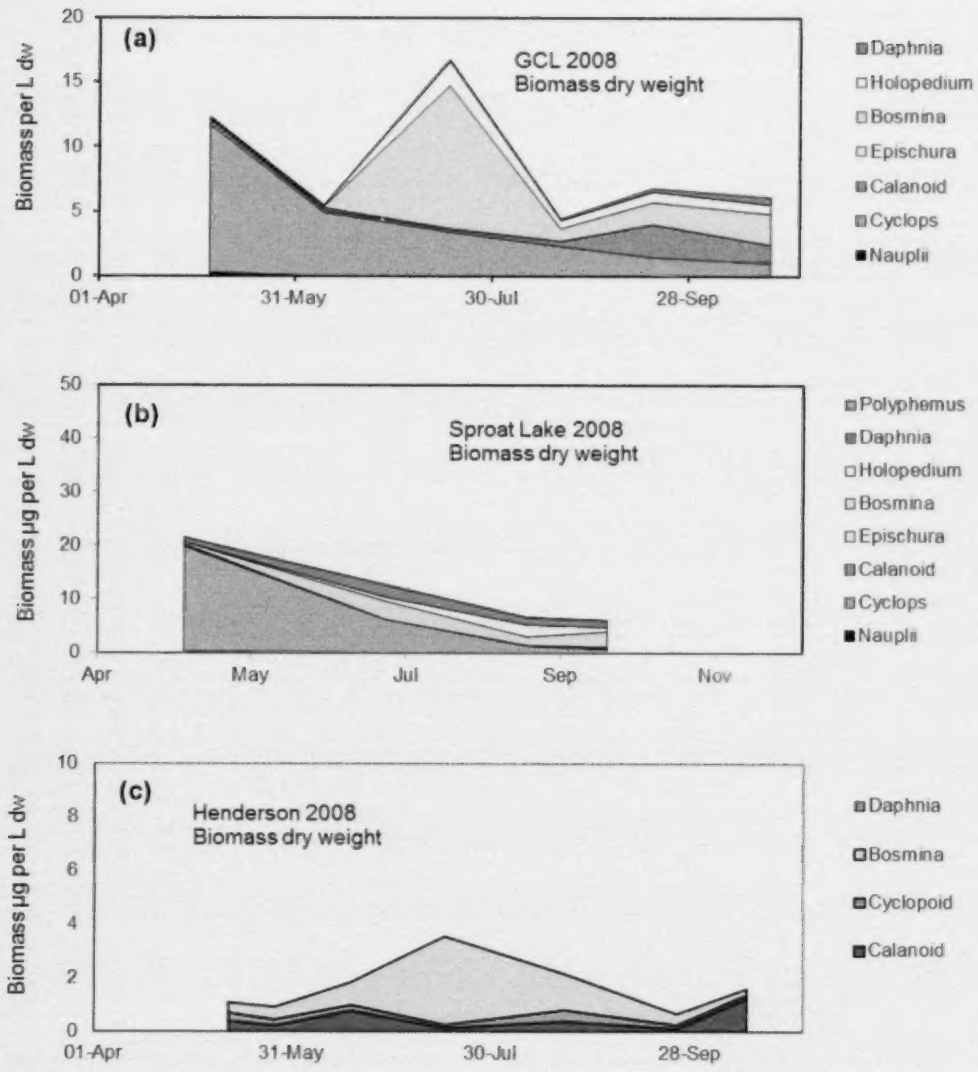



Figure 7. Year 2008 zooplankton biomasses as µg $L^{-1}$ dry weight. Note that the axis ranges are different. The samples were not Rigosha metered for net efficiency.

FISH DENSITIES, LENGTHS, AND WEIGHTS: Results are summarized in Table 7 below. Weights have been corrected for shrinkage due to the ethanol used as a preservative. Smolt lengths and weights suggest that Sproat Lake fish grew slightly faster than GCL fry and that both grew 4-5 times faster than fry from Henderson Lake. 95 % confidence intervals around the means of fish abundance are also provided. The mean of one or more winter survey values (Nov-Feb) is considered to be useable as a spring smolt production estimate when 95% confidence intervals suggest multiple estimates be treated as replicates. If winter survey values differ significantly, then the latest survey value is considered to represent the best annual estimate of smolt production.

Table 7. Year 2008 mean limnetic fish densities, lengths, and weights. Weights have been corrected for shrinkage due to the effect of the ethanol used as a preservative. SB= Stickleback.

| Sampling Date | Total Limnetic Fish Density | Limnetic Fish Density per ha | Conf. Intervals (%) | Sockeye Density per ha | Sockeye Mean Length (mm) | Sockeye Mean Weight (g) | Sockeye Sample Size (n) | SB Density per ha | SB Mean Length (mm) | SB Mean Weight (g) | SB Sample Size (n) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | | | | |
| 17-Jul-08 | 13,214,207 | 2,599 | 45 | 2,599 | 40 | 0.7 | 49 | 0 | 77 | 5.2 | 2 |
| 17-Nov-08 | 4,063,328 | 799 | 46 | 799 | 59 | 2.0 | 146 | 0 | | | |
| 04-Feb-09 | 3,755,739 | 739 | 30 | 739 | | | 0 | 0 | | | |
| 18-Apr to 13-May-09 | Smolts | | | | 79 | 4 | 478 | | | | |
| **(b) Sproat Lake** | | | | | | | | | | | |
| 23-Jul-08 | 5,540,818 | 1,468 | 27 | 1,468 | 33 | 0.27 | 17 | 0 | | | |
| 01-Dec-08 | 6,017,335 | 1,594 | 16 | 1,594 | 72 | 3.5 | 91 | 0 | | | |
| 15-Apr to 5-May-09 | Smolts | | | | 84 | 5.4 | 104 | | | | |
| **(c) Henderson Lake** | | | | | | | | | | | |
| 15-Jul-08 | 1,823,153 | 1,180 | 23 | 177 | 35 | 0.4 | 35 | 1,003 | 44 | 1 | 102 |
| 18-Nov-08 | 1,827,488 | 1,183 | 29 | 371 | 35 | 0.6 | 19 | 811 | 47 | 0.9 | 52 |
| 29-Jan-09 | 3,017,222 | 1,953 | 26 | 734 | 41 | 0.7 | 129 | 1,218 | 45 | 0.8 | 102 |
| 16-Apr-09 | Smolts | | | | 48 | 1.0 | 117 | | | | |

## YEAR 2009: GREAT CENTRAL, SPROAT, AND HENDERSON LAKES DATA SUMMARY

SAMPLING SCHEDULE FOR 2009

Table 8. Samples collected during 2009. N-25 = zooplankton sampled at night 0-25 m. D-50 = zooplankton sampled in the day 0-50 m. S = Schindler trap samples taken day and night. 0 = data not collected. TR = trip report available.

| Date surveyed | DFO chemistry | VIU chemistry | Temperature | Oxygen | Secchi | Phytoplankton 1,3,5 | Zooplankton | Rigosha | Acoustic Records | Biosampling fish | Smolts collected(2010) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake** | | | | | | | | | | | | |
| 4-May-09 | x | | x | 0 | x | | N-25 | 0 | | | | TR |
| 1-Jun-09 | | | | | | | | | x | x | | TR |
| 8-Jun-09 | x | x | x | 0 | x | | D-50 | 0 | | | | TR |
| 6-Jul-09 | x | x | x | 0 | x | | D-50 | 0 | | | | TR |
| 16-Jul-09 | | | | | | | | | x | x | | TR |
| 17-Aug-09 | x | x | x | 0 | x | x | D-50 | 0 | | | | TR |
| 9-Sep-09 | | | | | x | x | S | | | | | TR |
| 21-Sep-09 | x | x | x | x | x | x | D-50 | 0 | | | | TR |
| 19-Oct-09 | x | x | x | 0 | x | x | D-50 | 0 | | | | TR |
| 25-Nov-09 | | | | | | | | | x | x | | TR |
| 12-Jan-10 | | | | | | | | | x | x | | TR |
| 19-Apr-10 | | | | | | | | | | | x | TR |
| 5-May-10 | | | | | | | | | | | x | TR |
| **Sproat Lake** | | | | | | | | | | | | |
| 06-May-09 | x | | x | 0 | x | | N-25 | x | | | | TR |
| 08-Jun-09 | x | x | x | 0 | x | | D-50 | 0 | | | | TR |
| 09-Jun-09 | | | | | | | | | x | x | | TR |
| 15-Jun-09 | | | | | | | D-N | | | | | TR |
| 08-Jul-09 | x | x | x | 0 | x | | D-50 | 0 | | | | TR |
| 18-Aug-09 | x | x | x | 0 | x | x | D-50 | 0 | | | | TR |
| 24-Aug-09 | | | | | | | | | x | x | | TR |
| 09-Sep-09 | | | | | x | | S | | | | | TR |
| 22-Sep-09 | x | x | x | 0 | x | x | D-50 | 0 | | | | TR |
| 20-Oct-09 | x | x | x | 0 | x | x | D-50 | 0 | | | | TR |
| 30-Nov-09 | | | | | | | | | x | x | | TR |
| 13-Jan-10 | | | | | | | | | x | | | TR |
| 05-May-10 | | | | | | | | | | | x | TR |
| **Henderson** | | | | | | | | | | | | |
| 29-Apr-09 | x | | x | 0 | x | | N-25 | x | | | | TR |
| 13-Jul-09 | x | x | x | x | x | | D-50 | 0 | | | | TR |
| 01-Sep-09 | | | | | | | | | x | x | | TR |
| 15-Sep-09 | x | x | x | x | x | x | D-50 | 0 | | | | TR |
| 03-Feb-10 | | | | | | | | | x | | | TR |
| 12-May-10 | | | | | | | | | | | x | TR |
| 13-May-10 | | | | | | | | | | | x | TR |

TEMPERATURE AND SECCHI DEPTHS: Results in GCL and Sproat were similar (Table 9). Henderson had colder spring temperatures and water that was more turbid. Both of these characteristics would be expected to reduce productive capacity for juvenile sockeye salmon.

Table 9. Year 2009 water temperatures and Secchi depths.

**(a) Great Central Lake 2009**

| Depth (m) | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 04-May | 8-Jun | 6-Jul | 17-Aug | 21-Sep | 19-Oct |
| 0 | 10.0 | 18.7 | 20.0 | 22.6 | 19.6 | 14.7 |
| 2 | 9.6 | 17.8 | 20.1 | 22.1 | 19.5 | 14.8 |
| 4 | 9.3 | 16.8 | 20.0 | 21.7 | 18.9 | 14.8 |
| 6 | 9.0 | 15.9 | 18.3 | 21.5 | 18.8 | 14.8 |
| 8 | 8.8 | 13.7 | 15.6 | 21.2 | 18.7 | 14.8 |
| 10 | 8.6 | 11.3 | 13.8 | 17.7 | 18.4 | 14.8 |
| 12 | 7.2 | 9.9 | 11.1 | 12.5 | 14.5 | 13.1 |
| 14 | 6.2 | 8.8 | 9.1 | 10.6 | 10.4 | 11.4 |
| 16 | 5.9 | 7.6 | 7.6 | 8.1 | 8.5 | 9.2 |
| 18 | 5.7 | 6.5 | 6.8 | 7.1 | 7.0 | 7.7 |
| 20 | 5.5 | 6.0 | 6.2 | 6.4 | 6.2 | 6.6 |
| 22 | 5.2 | 5.8 | 5.8 | 6.0 | 5.8 | 6.1 |
| **Secchi Depth (m)** | 3.4 | 10.7 | 6.1 | 11.3 | 11.0 | 8.5 |

**(b) Sproat Lake 2009**

| Depth (m) | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 06-May-09 | 8-Jun-09 | 6-Jul-09 | 18-Aug-09 | 22-Sep-09 | 20-Oct-09 |
| 0 | 11.2 | 18.4 | 19.0 | 22.4 | 19.1 | 15.0 |
| 2 | 11.2 | 17.5 | 19.0 | 22.0 | 19.0 | 15.1 |
| 4 | 11.0 | 17.0 | 19.0 | 21.6 | 19.0 | 15.1 |
| 6 | 10.2 | 16.7 | 19.0 | 21.5 | 18.9 | 15.1 |
| 8 | 8.7 | 14.5 | 17.5 | 21.2 | 18.9 | 15.1 |
| 10 | 7.8 | 12.3 | 13.7 | 18.9 | 18.7 | 15.1 |
| 12 | 7.2 | 9.4 | 11.2 | 12.5 | 15.2 | 14.3 |
| 14 | 6.8 | 8.2 | 8.4 | 9.8 | 11.3 | 12.9 |
| 16 | 6.4 | 7.5 | 7.5 | 8.8 | 9.5 | 11.3 |
| 18 | 6.1 | 6.9 | 7.0 | 8.0 | 8.5 | 10.2 |
| 20 | 5.8 | 6.5 | 6.5 | 7.4 | 7.6 | 8.7 |
| 22 | 5.6 | 6.3 | 6.2 | 7.0 | 7.3 | 8.1 |
| **Secchi Depth (m)** | 9.1 | 10.5 | 12.0 | 15.0 | 15.5 | 12.3 |

(continued)

**(c) Henderson Lake 2009**

| Depth (m) | Temperature (°C) | | |
|---|---|---|---|
| | 29-Apr | 13-Jul | 15-Sep |
| 0 | 8.9 | 18.7 | 19.0 |
| 2 | 8.9 | 18.7 | 18.9 |
| 4 | 8.9 | 18.7 | 18.8 |
| 6 | 8.8 | 18.6 | 18.8 |
| 8 | 8.8 | 18.3 | 18.7 |
| 10 | 8.7 | 17.2 | 18.5 |
| 12 | 8.6 | 13.6 | 18.0 |
| 14 | 8.3 | 10.9 | 15.4 |
| 16 | 8.1 | 8.9 | 12.7 |
| 18 | 8.0 | 8.0 | 10.1 |
| 20 | 7.8 | 7.5 | 8.1 |
| 22 | 7.6 | 7.0 | 7.5 |
| **Secchi Depth (m)** | 8.4 | 5.9 | 9.5 |

WATER CHEMISTRY: Estimates for TP were much higher in GCL and Sproat Lake than they were in Henderson Lake (Table 10). Chlorophyll a concentrations were about the same in all three lakes. Epilimnetic nitrate concentrations declined rapidly in GCL and Sproat Lake, but remained higher in Henderson Lake. This reflects lower rates of algal productivity in Henderson Lake.

Table 10. Year 2009 water chemistry averaged over 2 stations in each lake. Chlorophyll a data are not corrected for phaeopigments.

| Sampling Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake 2009** | | | | | | | |
| 4-May-09 | 1, 3, 5 | 37.7 | 2.8 | 0.7 | 20 | 49.7 | 3.0 |
| 8-Jun-09 | 1, 3, 5 | 21.8 | 2.8 | 0.8 | 20 | 48.2 | 2.6 |
| 6-Jul-09 | 1, 3, 5 | 5.2 | 3.0 | 1.2 | 20 | 47.4 | 2.6 |
| 17-Aug-09 | 1, 3, 5 | 1.3 | 3.2 | 0.3 | 20 | 49.0 | 2.4 |
| 21-Sep-09 | 1, 3, 5 | 1.7 | 3.5 | 0.6 | 20 | 51.2 | 2.0 |
| 19-Oct-09 | 1, 3, 5 | 2.7 | 2.9 | 0.7 | 20 | 51.0 | 2.2 |
| **(b) Sproat Lake 2009** | | | | | | | |
| 6-May-09 | 1, 3, 5 | 17.9 | 2.9 | 0.5 | 20 | 35.4 | 3.2 |
| 8-Jun-09 | 1, 3, 5 | 6.9 | 4.0 | 0.6 | 20 | 32.3 | 3.2 |
| 8-Jul-09 | 1, 3, 5 | 2.0 | 2.5 | 0.2 | 20 | 27.1 | 3.2 |
| 18-Aug-09 | 1, 3, 5 | 1.9 | 2.7 | 0.2 | 20 | 21.9 | 2.8 |
| 22-Sep-09 | 1, 3, 5 | 1.9 | 2.0 | 0.3 | 20 | 21.9 | 2.5 |
| 20-Oct-09 | 1, 3, 5 | 2.6 | 2.3 | 0.6 | 20 | 20.0 | 2.5 |

(continued)

| Sampling Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| **(c) Henderson 2009** | | | | | | | |
| 29-Apr-09 | 1, 3, 5 | 37.2 | 1.0 | 0.6 | 20 | 41.5 | 0.7 |
| 13-Jul-09 | 1, 3, 5 | 17.5 | 0.6 | 0.7 | 20 | 43.7 | 0.1 |
| 15-Sep-09 | 1, 3, 5 | 20.4 | 0.6 | 0.7 | 20 | 48.4 | 0.2 |

Water chemistry analyzed at Vancouver Island University (Table 11) showed that total alkalinity and Calcium were highest in Sproat Lake, slightly lower in GCL, and lowest in Henderson Lake. The low Ca concentrations observed during the late summer in GCL and all summer in Henderson Lake may have negatively influenced chitin formation in *Daphnia*. Note the higher Na and Mg concentrations in Henderson Lake.

Table 11. Year 2009 summary of average, water chemistry data analyzed at Vancouver Island University.

| Sampling Date | Total alkalinity (ppm $CaCO_3$) | Na (ppm) | Mg (ppm) | Ca (ppm) |
|---|---|---|---|---|
| **(a) Great Central Lake** | | | | |
| 08-Jun-09 | 15.2 | 0.7 | 0.4 | 4.7 |
| 06-Jul-09 | 15.8 | 0.7 | 0.4 | 8.3 |
| 17-Aug-09 | 15.4 | 0.7 | 0.5 | 2.0 |
| 21-Sep-09 | 15.4 | 0.7 | 0.5 | 2.0 |
| 19-Oct-09 | 15.5 | 0.8 | 0.5 | 3.9 |
| **(b) Sproat Lake** | | | | |
| 08-Jun-09 | 26.5 | 1.0 | 0.7 | 8.0 |
| 08-Jul-09 | 27.3 | 1.1 | 0.7 | 4.7 |
| 18-Aug-09 | 27.3 | 1.1 | 0.9 | 3.5 |
| 22-Sep-09 | 26.3 | 1.1 | 0.9 | 3.7 |
| 19-Oct-09 | 26.0 | 1.1 | 0.8 | 7.7 |
| **(c) Henderson Lake** | | | | |
| 13-Jul-09 | 10.4 | 15.3 | 2.1 | 3.8 |
| 15-Sep-09 | 10.8 | 17.5 | 0.9 | 1.4 |

PHYTOPLANKTON BIOMASSES: Results were recorded from samples taken at 1,3, and 5m (combined) and also at 25m (Table 12; Figures 8, 9, and 10). The deep samples were intended to reveal sub-thermocline algal populations that were known from Sproat Lake but less certain from GCL and Henderson Lake. Densities, cell sizes, cell shapes, and biovolumes were recorded. One of the objectives of the phytoplankton counting procedure was to assess the relative availabilities of edible (grazable) and non-edible (non-grazable) algae. The data showed

that GCL had more total phytoplankton than either of the other lakes. Henderson had the least. GCL had relatively little phytoplankton at 25 m while Sproat Lake had more at 25 m than at 1-3-5 m. Additionally, Sproat had more edible algae at 25 m than at 1-3-5m. Henderson had slightly more edible phytoplankton than either of the other two lakes. Both GCL and Sproat had quite large populations of *Rhizosolenia* (now *Urosolenia*; Round et al. 1990), with more at the surface than deeper. Henderson Lake also had *Rhizosolenia*, but less than the other two. The large "edible" portion of the GCL plankton comprised *Uroglena* or *Uroglenopsis* with ovoid cells measuring 7 µm in diameter. This is an ideal size for zooplankton food, but before preservation, the cells were likely in colonies and it is difficult to say how many were available for consumption.

Table 12. Year 2009 total and edible phytoplankton biovolume. Values are expressed as $mm^3$ / $m^3$.

**(a) Great Central Lake 2009 (see also, Figure 8)**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 04-May-09 | 1,3,5 | 0 | 39 | 4 | 0 | 281 | 3 | 0 | 10 | 0 | 282 | 618 |
| 08-Jun-09 | 1,3,5 | 0 | 12 | 9 | 0 | 385 | 20 | 1 | 14 | 0 | 442 | 884 |
| 06-Jul-09 | 1,3,5 | 0 | 35 | 0 | 0 | 343 | 0 | 2 | 30 | 0 | 295 | 706 |
| 17-Aug-09 | 1,3,5 | 1 | 13 | 0 | 0 | 32 | 1 | 2 | 12 | 0 | 12 | 72 |
| 21-Sep-09 | 1,3,5 | 4 | 7 | 3 | 0 | 23 | 3 | 5 | 20 | 0 | 2 | 67 |
| 19-Oct-09 | 1,3,5 | 5 | 8 | 13 | 0 | 22 | 1 | 13 | 28 | 0 | 2 | 91 |
| 04-May-09 | 25 | 0 | 17 | 9 | 0 | 4 | 5 | 0 | 10 | 0 | 63 | 108 |
| 08-Jun-09 | 25 | 0 | 19 | 9 | 0 | 13 | 5 | 0 | 2 | 0 | 98 | 147 |
| 06-Jul-09 | 25 | 0 | 10 | 2 | 0 | 12 | 2 | 0 | 1 | 0 | 165 | 192 |
| 17-Aug-09 | 25 | 0 | 4 | 14 | 0 | 10 | 1 | 0 | 6 | 0 | 43 | 79 |
| 21-Sep-09 | 25 | 2 | 7 | 6 | 0 | 14 | 6 | 0 | 17 | 0 | 129 | 180 |
| 19-Oct-09 | 25 | 5 | 8 | 13 | 0 | 22 | 1 | 13 | 28 | 0 | 2 | 91 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 04-May-09 | 1,3,5 | 0 | 18 | 4 | 0 | 42 | 3 | 0 | 6 | 0 | 31 | 105 |
| 08-Jun-09 | 1,3,5 | 0 | 11 | 9 | 0 | 85 | 20 | 1 | 11 | 0 | 21 | 158 |
| 06-Jul-09 | 1,3,5 | 0 | 7 | 0 | 0 | 28 | 0 | 2 | 28 | 0 | 43 | 108 |
| 17-Aug-09 | 1,3,5 | 0 | 13 | 0 | 0 | 14 | 1 | 2 | 11 | 0 | 1 | 42 |
| 21-Sep-09 | 1,3,5 | 0 | 4 | 3 | 0 | 22 | 3 | 5 | 19 | 0 | 1 | 56 |
| 19-Oct-09 | 1,3,5 | 0 | 5 | 13 | 0 | 10 | 1 | 13 | 24 | 0 | 0 | 66 |
| 04-May-09 | 25 | 0 | 13 | 9 | 0 | 4 | 5 | 0 | 10 | 0 | 4 | 45 |
| 08-Jun-09 | 25 | 0 | 17 | 9 | 0 | 13 | 5 | 0 | 2 | 0 | 9 | 54 |
| 06-Jul-09 | 25 | 0 | 2 | 2 | 0 | 6 | 2 | 0 | 1 | 0 | 96 | 109 |
| 17-Aug-09 | 25 | 0 | 1 | 14 | 0 | 8 | 1 | 0 | 6 | 0 | 9 | 39 |
| 21-Sep-09 | 25 | 0 | 4 | 6 | 0 | 10 | 6 | 0 | 17 | 0 | 31 | 72 |
| 19-Oct-09 | 25 | 0 | 3 | 11 | 0 | 8 | 1 | 0 | 3 | 0 | 32 | 57 |

(continued)

**(b) Sproat Lake 2009 (see also, Figure 9)**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 06-May-09 | 1,3,5 | 0 | 33 | 4 | 0 | 37 | 2 | 0 | 19 | 0 | 701 | 795 |
| 08-Jun-09 | 1,3,5 | 0 | 8 | 2 | 0 | 12 | 1 | 1 | 10 | 0 | 550 | 585 |
| 08-Jul-09 | 1,3,5 | 0 | 4 | 1 | 0 | 17 | 0 | 7 | 9 | 0 | 39 | 77 |
| 18-Aug-09 | 1,3,5 | 0 | 9 | 4 | 0 | 14 | 0 | 13 | 6 | 0 | 0 | 46 |
| 22-Sep-09 | 1,3,5 | 1 | 11 | 2 | 0 | 16 | 1 | 22 | 10 | 0 | 0 | 63 |
| 20-Oct-09 | 1,3,5 | 1 | 10 | 8 | 0 | 32 | 1 | 6 | 11 | 0 | 4 | 73 |
| 06-May-09 | 20 | 1 | 14 | 19 | 0 | 57 | 4 | 0 | 14 | 0 | 272 | 379 |
| 08-Jun-09 | 20 | 0 | 14 | 17 | 0 | 122 | 6 | 0 | 9 | 0 | 306 | 474 |
| 08-Jul-09 | 20 | 0 | 6 | 15 | 0 | 74 | 4 | 1 | 12 | 0 | 602 | 714 |
| 18-Aug-09 | 20 | 0 | 4 | 5 | 0 | 36 | 1 | 0 | 16 | 0 | 83 | 145 |
| 22-Sep-09 | 20 | 0 | 17 | 13 | 0 | 12 | 5 | 1 | 11 | 0 | 42 | 102 |
| 20-Oct-09 | 20 | 0 | 3 | 10 | 0 | 13 | 5 | 1 | 24 | 0 | 16 | 72 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 06-May-09 | 1,3,5 | 0 | 33 | 4 | 0 | 37 | 2 | 0 | 17 | 0 | 72 | 164 |
| 08-Jun-09 | 1,3,5 | 0 | 8 | 2 | 0 | 9 | 1 | 1 | 10 | 0 | 42 | 73 |
| 08-Jul-09 | 1,3,5 | 0 | 3 | 1 | 0 | 17 | 0 | 7 | 9 | 0 | 6 | 42 |
| 18-Aug-09 | 1,3,5 | 0 | 4 | 4 | 0 | 14 | 0 | 13 | 3 | 0 | 0 | 38 |
| 22-Sep-09 | 1,3,5 | 1 | 8 | 2 | 0 | 16 | 1 | 22 | 9 | 0 | 0 | 59 |
| 20-Oct-09 | 1,3,5 | 1 | 2 | 8 | 0 | 31 | 1 | 6 | 11 | 0 | 2 | 63 |
| 06-May-09 | 20 | 0 | 10 | 19 | 0 | 42 | 4 | 0 | 14 | 0 | 23 | 112 |
| 08-Jun-09 | 20 | 0 | 8 | 17 | 0 | 58 | 6 | 0 | 9 | 0 | 40 | 137 |
| 08-Jul-09 | 20 | 0 | 4 | 0 | 0 | 52 | 4 | 1 | 12 | 0 | 104 | 178 |
| 18-Aug-09 | 20 | 0 | 4 | 5 | 0 | 34 | 1 | 0 | 14 | 0 | 83 | 141 |
| 22-Sep-09 | 20 | 0 | 4 | 13 | 0 | 12 | 5 | 1 | 11 | 0 | 28 | 75 |
| 20-Oct-09 | 20 | 0 | 2 | 10 | 0 | 13 | 5 | 1 | 13 | 0 | 12 | 55 |

(continued)

**(c) Henderson Lake 2009 (see also, Figure 10)**

| Sampling Date | Depth(m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 29-Apr-09 | 1,3,5 | 0 | 41 | 4 | 0 | 97 | 1 | 1 | 26 | 0 | 85 | 255 |
| 13-Jul-09 | 1,3,5 | 0 | 38 | 3 | 0 | 36 | 11 | 4 | 8 | 0 | 138 | 239 |
| 15-Sep-09 | 1,3,5 | 0 | 13 | 4 | 0 | 42 | 24 | 1 | 11 | 0 | 55 | 148 |
| 29-Apr-09 | 25 | 0 | 14 | 8 | 0 | 21 | 1 | 0 | 5 | 0 | 70 | 119 |
| 13-Jul-09 | 25 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 45 | 52 |
| 15-Sep-09 | 25 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 7 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 29-Apr-09 | 1,3,5 | 0 | 41 | 4 | 0 | 86 | 1 | 1 | 26 | 0 | 14 | 172 |
| 13-Jul-09 | 1,3,5 | 0 | 23 | 3 | 0 | 35 | 11 | 4 | 8 | 0 | 7 | 92 |
| 15-Sep-09 | 1,3,5 | 0 | 13 | 4 | 0 | 42 | 24 | 1 | 11 | 0 | 55 | 148 |
| 29-Apr-09 | 25 | 0 | 9 | 8 | 0 | 21 | 1 | 0 | 5 | 0 | 10 | 54 |
| 13-Jul-09 | 25 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 5 | 11 |
| 15-Sep-09 | 25 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 7 |

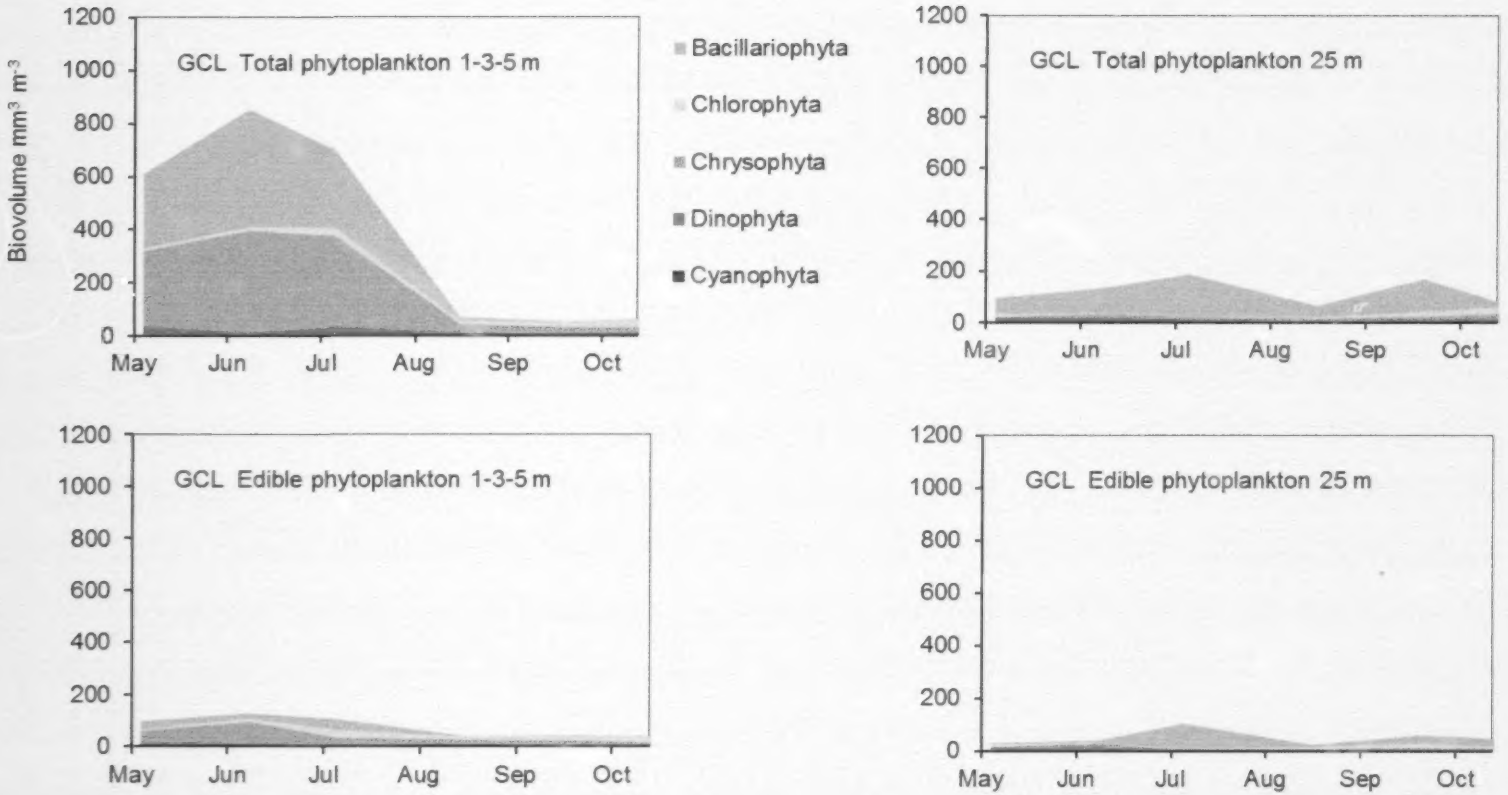



Figure 8. Great Central Lake 2009 total and edible phytoplankton biomass recorded as $mm^3 m^{-3}$, which approximates $\mu g L^{-1}$ wet weight. Samples were collected at 1, 3, and 5 m combined and at 25m.

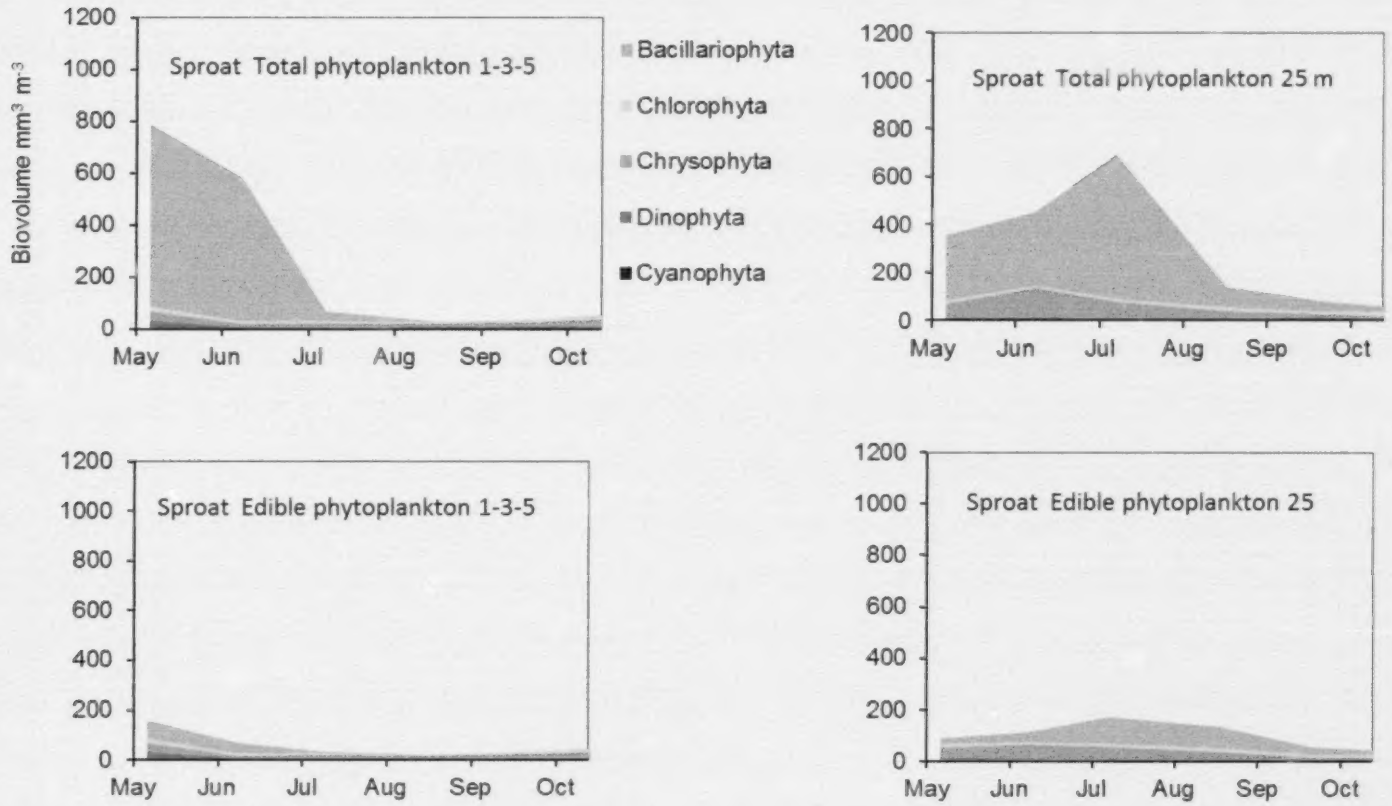



Figure 9. Sproat Lake 2009 total and edible phytoplankton biomass recorded as $mm^3\ m^{-3}$, which approximates $\mu g\ L^{-1}$ wet weight. Samples were collected at 1, 3, and 5 m combined and at 25m.

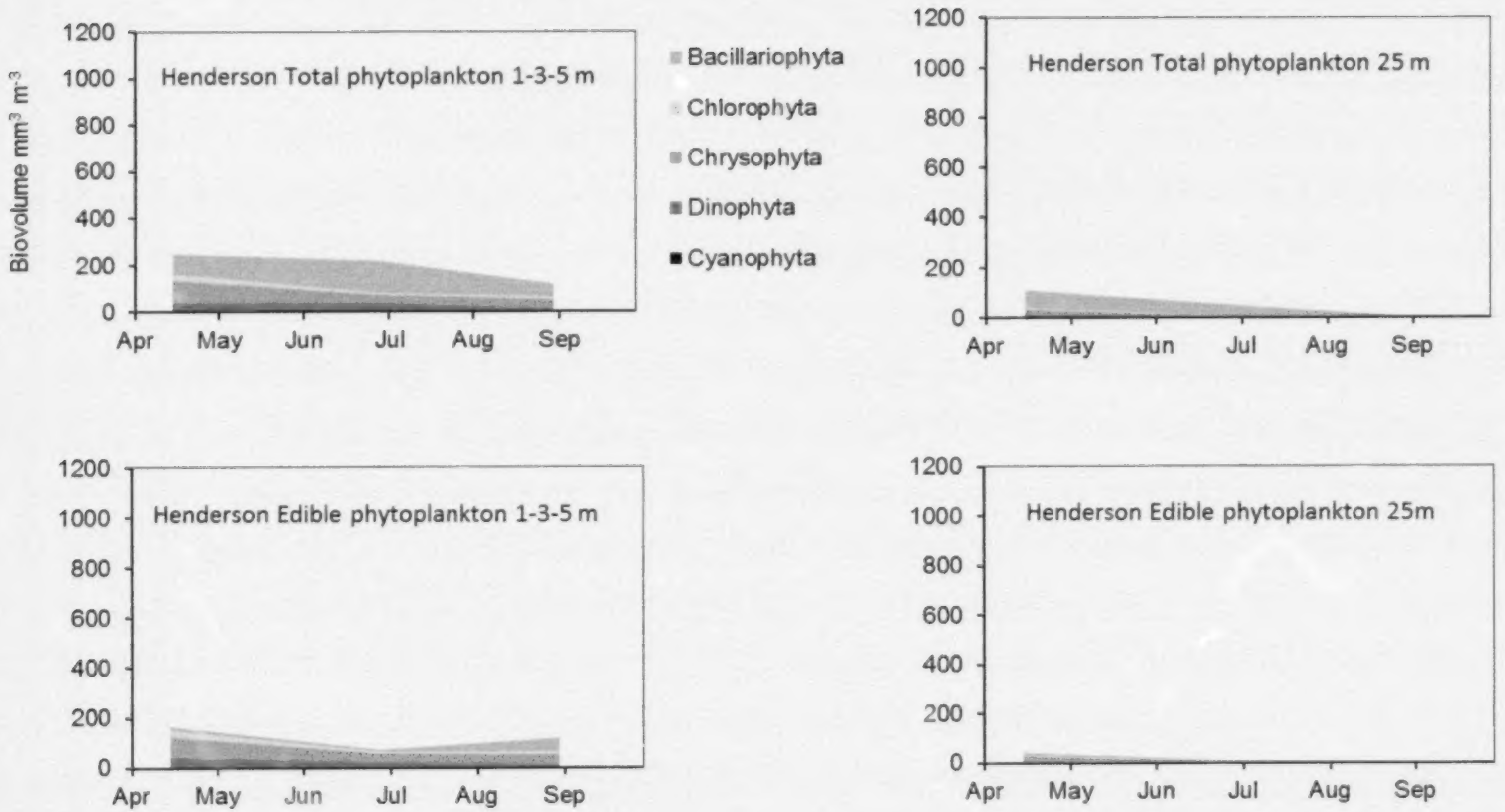



Figure 10. Henderson Lake 2009 total and edible phytoplankton biomass recorded as $mm^3\ m^{-3}$, which approximates $\mu g\ L^{-1}$ wet weight. Samples were collected at 1, 3, and 5 m combined and at 25m.

ZOOPLANKTON BIOMASSES: Estimates in 2009 were highest in Sproat > GCL > Henderson Lake (Table 13, Figure 11a, b, and c, Figure 12). Species diversity was about equal in all three lakes. Given that Henderson Lake edible phytoplankton biomasses were higher than they were in GCL and Sproat Lakes (Figures 8, 9, and 10), it seems likely that zooplankton were limited by factors other than simple food availability. Perhaps low temperatures and higher turbidity (Table 9) were implicated. Note that *Daphnia* were common only in Sproat Lake.

Table 13. Year 2009 zooplankton density per L and biomass as µg/L dry weight.

**(a) Great Central Lake 2009 (see also, Figure 11a)**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifer | Chironomid |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 04-May-09 | 4.08 | 1.62 | 0.00 | 0.02 | 0.58 | 0.00 | 0.01 | 0.00 | 0.00 | 1.05 | 0.00 |
| 08-Jun-09 | 1.55 | 0.98 | 0.01 | 0.02 | 0.55 | 0.01 | 0.02 | 0.00 | 0.00 | 0.93 | 0.00 |
| 06-Jul-09 | 0.88 | 0.80 | 0.01 | 0.08 | 1.65 | 1.10 | 0.01 | 0.00 | 0.00 | 0.37 | 0.00 |
| 17-Aug-09 | 0.30 | 0.19 | 0.01 | 0.17 | 0.23 | 0.13 | 0.02 | 0.00 | 0.05 | 0.04 | 0.00 |
| 21-Sep-09 | 0.20 | 0.59 | 0.00 | 0.22 | 0.20 | 0.26 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| 19-Oct-09 | 0.29 | 0.52 | 0.00 | 0.24 | 0.53 | 0.49 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 04-May-09 | 7.79 | 0.36 | 0.00 | 0.18 | 0.50 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| 08-Jun-09 | 5.61 | 0.14 | 0.21 | 0.18 | 0.43 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| 06-Jul-09 | 3.00 | 0.21 | 0.25 | 0.54 | 1.57 | 2.61 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17-Aug-09 | 1.14 | 0.00 | 0.29 | 1.00 | 0.82 | 0.57 | 0.11 | 0.00 | 0.11 | 0.00 | 0.00 |
| 21-Sep-09 | 0.64 | 0.00 | 0.07 | 1.25 | 0.25 | 1.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19-Oct-09 | 0.71 | 0.00 | 0.00 | 1.79 | 0.54 | 2.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

(continued)

**(b) Sproat Lake 2009 (see also, Figure 11b)**

| Sampling Date | Cyclopoid adult and copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Scapholeberis* | Rotifer | Chironomid |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 06-May-09 | 6.16 | 2.26 | 0.01 | 0.00 | 0.11 | 0.00 | 0.13 | 0.00 | 0.00 | 0.12 | 0.00 |
| 08-Jun-09 | 1.55 | 1.32 | 0.01 | 0.00 | 0.10 | 0.02 | 0.10 | 0.00 | 0.00 | 0.34 | 0.00 |
| 08-Jul-09 | 0.53 | 2.26 | 0.00 | 0.00 | 0.60 | 0.25 | 0.20 | 0.00 | 0.00 | 0.60 | 0.00 |
| 18-Aug-09 | 0.24 | 1.40 | 0.00 | 0.00 | 0.89 | 0.29 | 0.17 | 0.00 | 0.00 | 0.52 | 0.00 |
| 22-Sep-09 | 0.20 | 1.40 | 0.00 | 0.00 | 0.97 | 0.19 | 0.26 | 0.00 | 0.00 | 0.78 | 0.00 |
| 20-Oct-09 | 0.11 | 1.06 | 0.00 | 0.01 | 1.08 | 0.07 | 0.29 | 0.00 | 0.00 | 0.58 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 06-May-09 | 18.77 | 0.37 | 0.14 | 0.00 | 0.20 | 0.00 | 0.63 | 0.00 | 0.00 | 0.06 | 0.00 |
| 08-Jun-09 | 4.74 | 1.00 | 0.14 | 0.00 | 0.09 | 0.03 | 0.37 | 0.00 | 0.00 | 0.00 | 0.00 |
| 08-Jul-09 | 1.50 | 0.18 | 0.00 | 0.00 | 0.61 | 0.32 | 0.68 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18-Aug-09 | 0.71 | 0.06 | 0.00 | 0.00 | 1.00 | 0.49 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22-Sep-09 | 0.77 | 0.14 | 0.00 | 0.00 | 3.29 | 0.43 | 0.97 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20-Oct-09 | 0.43 | 0.09 | 0.00 | 0.11 | 1.11 | 0.14 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**(c) Henderson Lake 2009 (see also, Figure 11c, Figure 12)**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifer | Chironomid |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 29-Apr-09 | 0.02 | 0.37 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 13-Jul-09 | 0.08 | 0.50 | 0.04 | 0.05 | 1.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 |
| 15-Sep-09 | 0.05 | 0.21 | 0.00 | 0.11 | 0.08 | 0.00 | 0.00 | 0.00 | 0.03 | 0.05 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 29-Apr-09 | 0.07 | 0.07 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13-Jul-09 | 0.21 | 0.14 | 0.07 | 0.07 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15-Sep-09 | 0.14 | 0.00 | 0.00 | 0.32 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

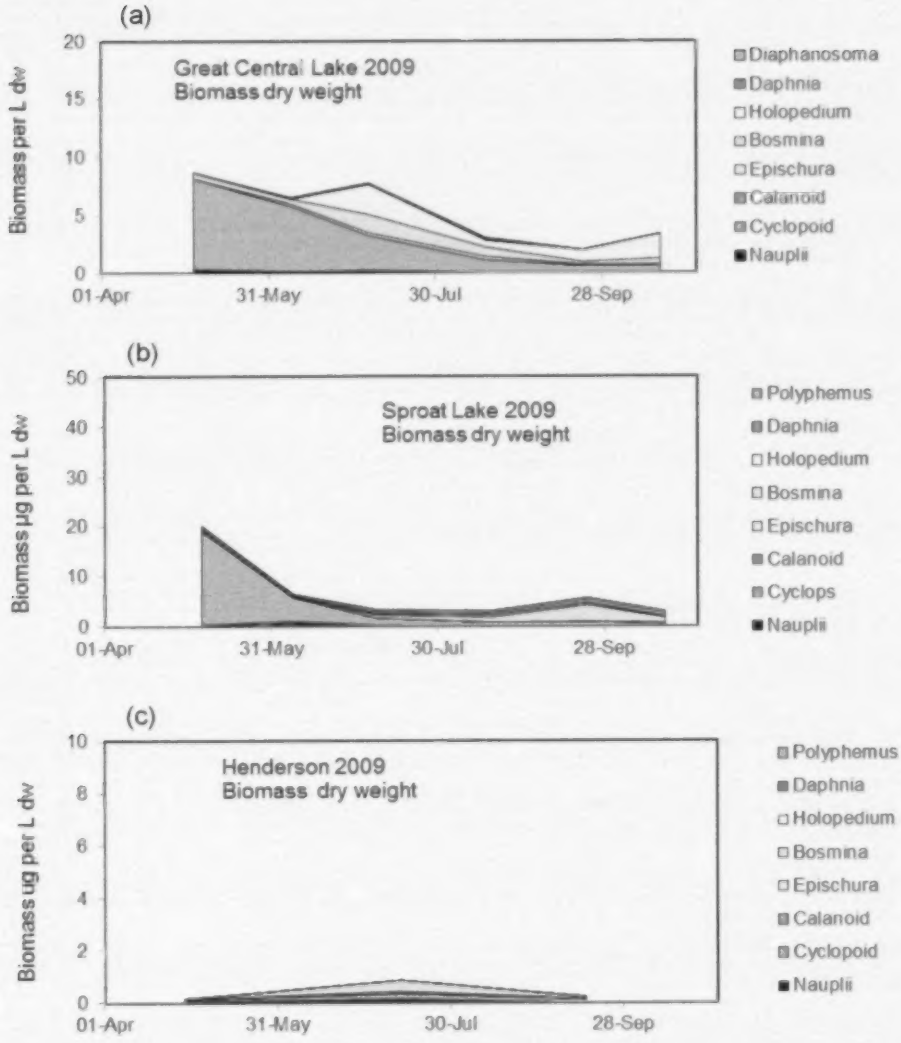



Figure 11. Year 2009 zooplankton biomasses as µg $L^{-1}$ dry weight. Note differences in the y-axis. Samples were not metered for net efficiency.

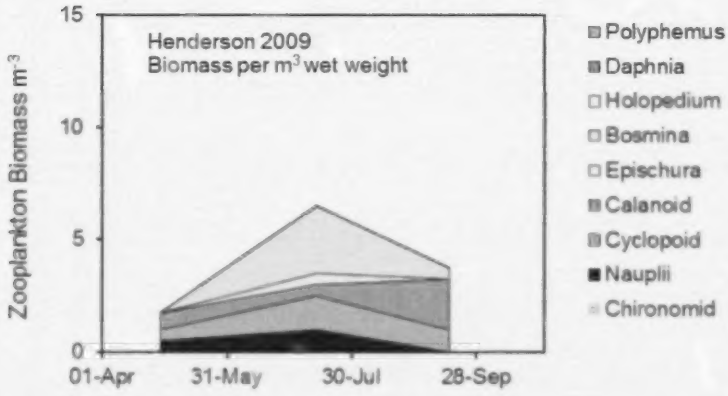



Figure 12. Year 2009 Henderson Lake zooplankton biomasses as µg $L^{-1}$ wet weight. To show species diversity, the Y-axis is plotted as 1/10th of the axes plotted in Figure 11c.

Comparison of day versus night and 25 versus 50 m vertical haul samples showed that the highest zooplankton densities were obtained during the night and at 25 m depth. Two way ANOVA (next page) showed significant day versus night and 25 versus 50 m effects for *Bosmina*, *Cyclops*, and *Daphnia*. Nauplii were significant only for day-night, but not depth. Calanoids were not analyzed due to small population densities and rotifers were not analyzed because they are not consumed by fish.

Table 14. Average (n=4) zooplankton densities per L from night-day, 25 and 50 m vertical hauls sampled on June 9, 2009 at Sproat Lake.

| Treatments | | Nauplii | Rotifers | Bosminids | Cyclopoids | Calanoids | *Daphnia* |
|---|---|---|---|---|---|---|---|
| Day | 25m | 6.58 | 1.23 | 0.66 | 4.33 | 0.01 | 0.24 |
| Day | 50m | 2.25 | 0.28 | 0.33 | 1.72 | 0.01 | 0.15 |
| Night | 25m | 4.96 | 3.44 | 1.11 | 3.40 | 0.01 | 0.75 |
| Night | 50m | 3.15 | 1.38 | 0.44 | 1.47 | 0.00 | 0.44 |

Table 15. Tests of between-subjects effects.

**1. Dependent Variable: nauplii**

| Source | Type III Sum Of Squares | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| Corrected Model | 44.652[a] | 3 | 14.884 | 9.103 | 0.002 |
| Intercept | 286.710 | 1 | 286.710 | 175.345 | 0.000 |
| daynight | 0.522 | 1 | 0.522 | 0.319 | 0.582 |
| Depth | 37.792 | 1 | 37.792 | 23.113 | 0.000 |
| daynight * Depth | 6.338 | 1 | 6.338 | 3.876 | 0.073 |
| Error | 19.621 | 12 | 1.635 | | |
| Total | 350.982 | 16 | | | |
| Corrected Total | 64.273 | 15 | | | |

a. R Squared = 0.695 (Adjusted R Squared = 0.619)

**2. Dependent Variable: *Bosmina***

| Source | Type III Sum Of Squares | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| Corrected Model | 1.430[a] | 3 | 0.477 | 12.928 | 0.000 |
| Intercept | 6.414 | 1 | 6.414 | 173.937 | 0.000 |
| daynight | 0.311 | 1 | 0.311 | 8.429 | 0.013 |
| Depth | 0.995 | 1 | 0.995 | 26.985 | 0.000 |
| daynight * Depth | 0.124 | 1 | 0.124 | 3.370 | 0.091 |
| Error | 0.442 | 12 | 0.037 | | |
| Total | 8.286 | 16 | | | |
| Corrected Total | 1.873 | 15 | | | |

a. R Squared = 0.764 (Adjusted R Squared = 0.705)

**3. Dependent Variable: *Cyclops***

| Source | Type III Sum Of Squares | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| Corrected Model | 22.402[a] | 3 | 7.467 | 34.983 | 0.000 |
| Intercept | 119.137 | 1 | 119.137 | 558.129 | 0.000 |
| daynight | 1.381 | 1 | 1.381 | 6.488 | 0.026 |
| Depth | 20.566 | 1 | 20.566 | 96.348 | 0.000 |
| daynight * Depth | 0.456 | 1 | 0.456 | 2.134 | 0.170 |
| Error | 2.562 | 12 | 0.213 | | |
| Total | 144.101 | 16 | | | |
| Corrected Total | 24.964 | 15 | | | |

a. R Squared = 0.897 (Adjusted R Squared = 0.872)

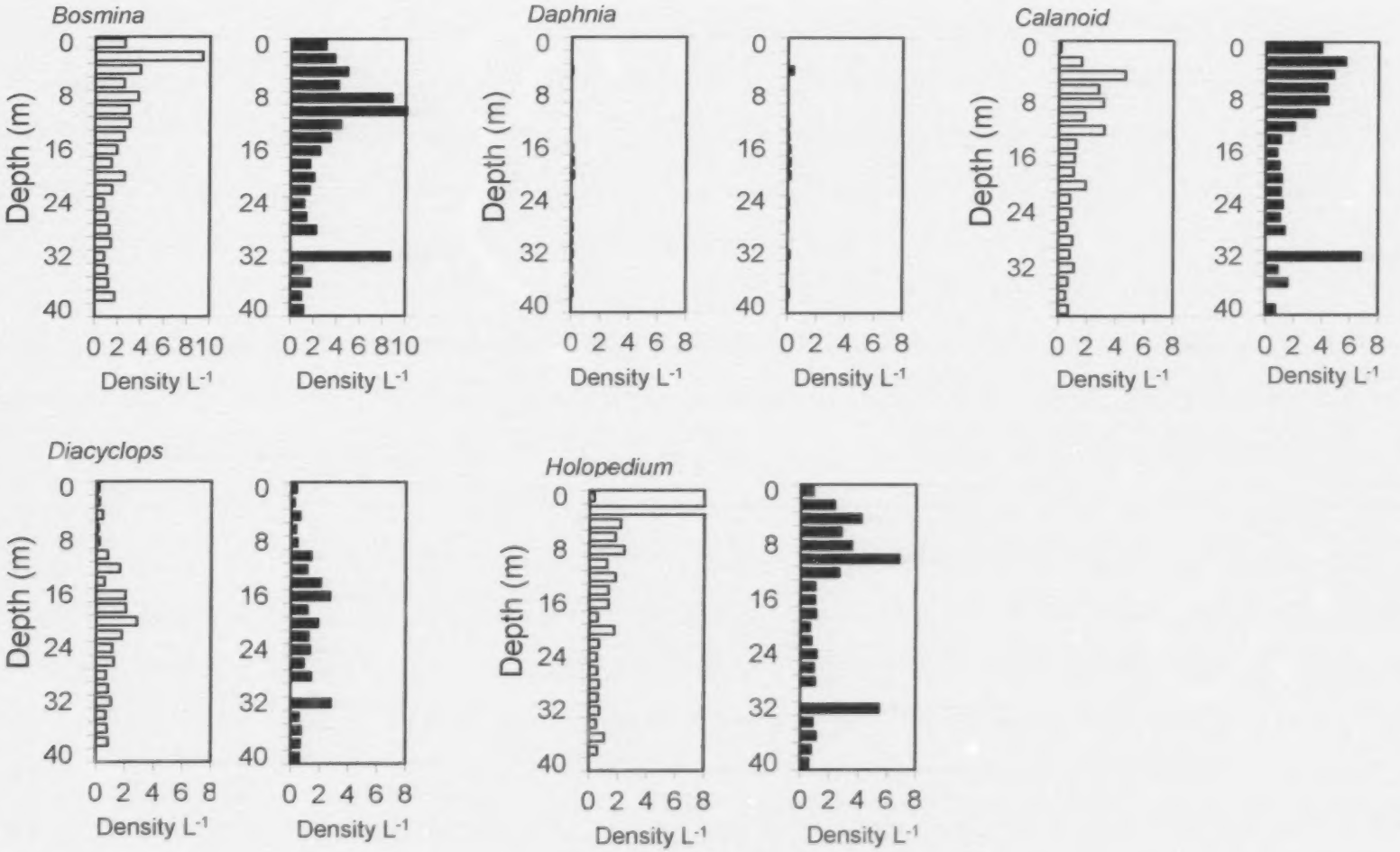
**4. Dependent Variable: *Daphnia***

| Source | Type III Sum Of Squares | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| Corrected Model | 0.844[a] | 3 | 0.281 | 20.064 | 0.000 |
| Intercept | 2.512 | 1 | 2.512 | 179.072 | 0.000 |
| daynight | 0.640 | 1 | 0.640 | 45.619 | 0.000 |
| Depth | 0.156 | 1 | 0.156 | 11.121 | 0.006 |
| daynight * Depth | 0.048 | 1 | 0.048 | 3.450 | 0.88 |
| Error | 0.168 | 12 | 0.014 | | |
| Total | 3.525 | 16 | | | |
| Corrected Total | 1.013 | 15 | | | |

a. R Squared = 0.834 (Adjusted R Squared = 0.792)

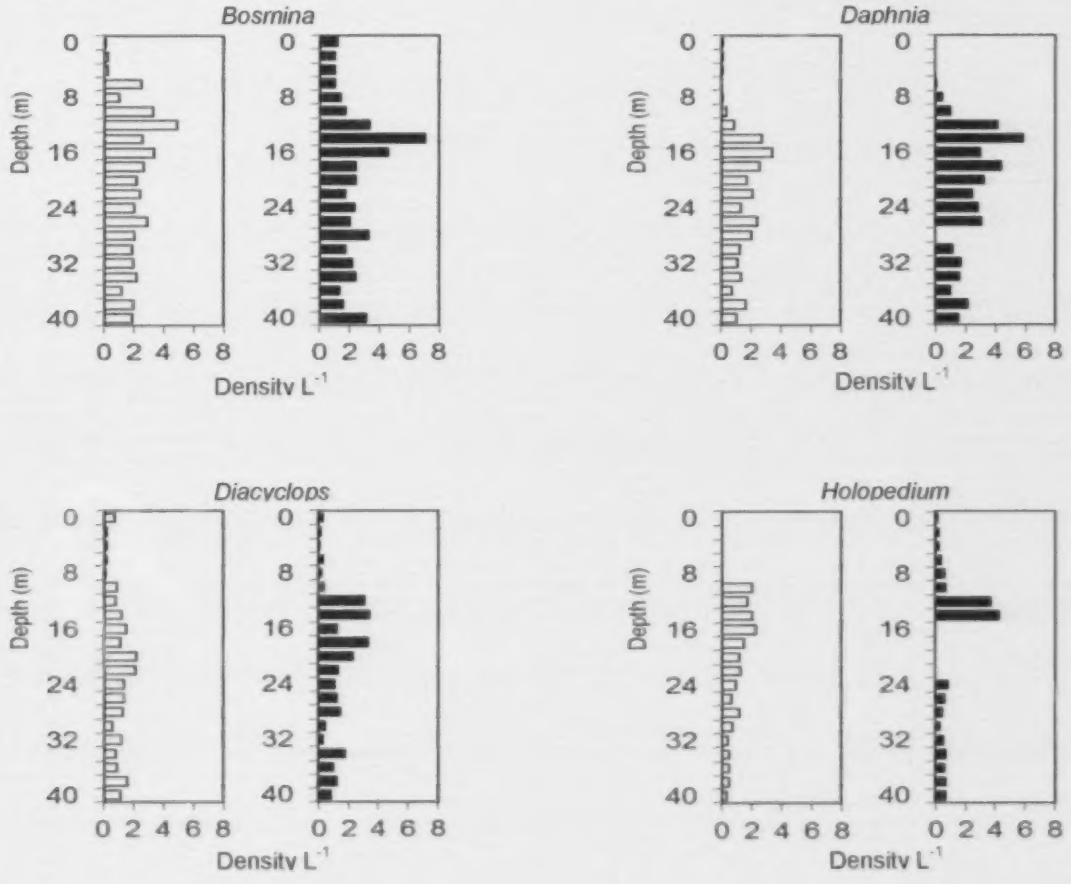
SCHINDLER TRAP SAMPLES: This method of sampling confirmed that *Daphnia* were more abundant in Sproat Lake than in GCL (Figures 13 and 14) and absent from the Henderson Lake samples taken in 2010 (Figure 17). *Bosmina* were found in Henderson Lake and were more abundant in GCL and Sproat. In GCL and Sproat, *Bosmina* moved deeper at night. In the Henderson Lake samples taken in 2010 (Figure 17) vertical migration was not as clear.

Figure 13. September 2009 Great Central Lake zooplankton depth distributions based on Schindler Trap samples. The Schindler trap sampled 30 L. Yellow is day and black is night. Calanoid = *Skistodiaptomus*.



In the Henderson Lake samples taken in 2010 (Figure 17), *Skistodiaptomus* (i.e. Calanoid) were found concentrated in the hypolimnion during the day and in the epilimnion during the night. In GCL, this was less obvious and in Sproat Lake, *Skistodiaptomus* densities were very low. *Diacyclops* remained in the hypolimnion both night and day in all three lakes. In Sproat Lake, *Daphnia* also remained in the hypolimnion. Sproat Lake *Daphnia* were a prime food source for juvenile sockeye and may have avoided predation by remaining in deep waters during the day. In Sproat Lake, they were also able to take advantage of the dense phytoplankton populations found below the thermocline.

Figure 14. September 2009 Sproat Lake zooplankton depth distributions based on Schindler Trap samples. The Schindler trap sampled 30 L. Yellow is day and black is night. *Skistodiaptomus* (calanoid) is not shown because their densities were near zero.



FISH DENSITIES, LENGTHS AND WEIGHTS: Results for 2009 are summarized in Table 16. Smolt lengths and weights suggest that GCL and Sproat Lake fish grew at about the same rates, and grew about twice as fast as the fry from Henderson Lake (unfertilized). 95 % confidence intervals around the means of fish abundance are also provided. The mean of one or more winter survey values (Nov-Feb) is considered to be useable as a spring smolt production estimate when 95% confidence intervals suggest multiple estimates be treated as replicates. If winter survey values differ significantly, then the latest survey value is considered to represent the best annual estimate of smolt production.

Table 16. Year 2009, mean limnetic fish densities, lengths, and weights and, smolt lengths and weights. Weights have been corrected for shrinking due to the effect of the ethanol used as a preservative.

| Sampling Date | Total Limnetic Fish Density | Limnetic Fish Density per ha | Conf. Limits (%) | Sockeye Density per ha | SB Density per ha | Sockeye Mean Length (mm) | Sockeye Mean Weight (g) | Sample Size (n) |
|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | |
| 16-Jul-09 | 17,282,022 | 3,400 | 47 | 3,400 | 0 | 50 | 1.1 | 35 |
| 25-Nov-09 | 5,171,366 | 1,000 | 20 | 1,000 | 0 | 61 | 2.2 | 51 |
| 11-Jan-10 | 7,593,187 | 1,500 | 40 | 1,500 | 0 | 52 | 1.3 | 114 |
| 19-Apr-10 | Smolts | | | | | 85 | 5.9 | 6 |
| 05-May-10 | Smolts | | | | | 76 | 4.5 | 161 |
| **(b) Sproat Lake** | | | | | | | | |
| 24-Aug-09 | 7,596,484 | 2,000 | 20 | 2,000 | 0 | 51 | 1.4 | 41 |
| 30-Nov-09 | 2,450,742 | 600 | 19 | 600 | 0 | 81 | 4.6 | 2 |
| 13-Jan-10 | 4,979,378 | 1,300 | 12 | 1,300 | 0 | | | no trawl |
| 05-May-10 | Smolts | | | | | 82 | 5.5 | 10 |
| **(c) Henderson Lake** | | | | | | | | |
| 01-Sep-09 | 3,243,639 | 2,099 | 25 | 988 | 0 | 51 | 1.5 | 65 |
| 03-Feb-10 | 1,389,207 | 899 | 22 | 813 | 0 | 54 | 1.2 | 40 |
| 12-May-10 | Smolts | | | | | 48 | 1.3 | 25 |
| 13-May-10 | Smolts | | | | | 59 | 2.1 | 91 |

## YEAR 2010: GREAT CENTRAL, SPROAT, AND HENDERSON LAKES DATA SUMMARY

SAMPLING SCHEDULE FOR 2010

Table 17. Samples collected during 2010. x = sample collected. N-25 = zooplankton sampled at night from 0-25 m. D-50 = zooplankton sampled in the day from 0-50 m. 0 = data not collected. TR = trip report available.

| Date surveyed | DFO chemistry | VIU chemistry | Temperature | Oxygen | Secchi | Phytoplankton 1,3,5 | Zooplankton | Rigosha metered | Acoustic Records | Biosampled fish | Smolts (2011) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2010** | | | | | | | | | | | | |
| 22-Apr-10 | x | x | x | x | x | x | N-25 | x | | | | TR |
| 07-Jun-10 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 26-Jul-10 | x | x | x | 0 | x | x | D-50 | x | | | | TR |
| 06-Aug-10 | | | | | | | | | | x | | TR |
| 30-Aug-10 | | | | | | | | | x | x | | TR |
| 27-Sep-10 | x | x | x | 0 | x | x | | x | | | | TR |
| 01-Dec-10 | | x | | | | | | | x | x | | TR |
| 08-May-11 | | | | | | | | | | | x | TR |
| **Sproat Lake 2010** | | | | | | | | | | | | |
| 21-Apr-10 | x | x | x | x | x | x | N-25 | x | | | | TR |
| 08-Jun-10 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 10-Jun-10 | | | | | | | | | | x | | TR |
| 26-Jul-10 | x | x | x | 0 | x | x | D-50 | x | | | | TR |
| 24-Aug-10 | | | | | | | | | x | | | TR |
| 27-Sep-10 | x | x | x | 0 | x | x | | x | | | | TR |
| 30-Nov-10 | | x | | | | | | | | x | | TR |
| 28-Apr-11 | | | | | | | | | | | x | TR |
| 08-May-11 | | | | | | | | | | | x | TR |
| **Henderson Lake 2010** | | | | | | | | | | | | |
| 27-Apr-10 | x | x | x | x | x | x | N-25 | x | | | | TR |
| 14-Jun-10 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 16-Jun-10 | | | | | | | | | | x | | TR |
| 27-Jul-10 | x | x | x | 0 | x | x | D-50 | x | | | | TR |
| 31-Aug-10 | | | | | | | | | x | | | TR |
| 29-Sep-10 | x | x | x | 0 | x | x | D-50 | x | | | | TR |
| 31-Jan-11 | | | | | | | | | | x | | TR |
| 26-Apr-11 | | | | | | | | | | | x | TR |

TEMPERATURES AND SECCHI DEPTHS: Results from GCL and Sproat lakes were similar (Table 18). Henderson Lake had water that was more turbid. This would be expected to reduce productive capacity for algae and perhaps for juvenile sockeye salmon.

Table 18. Year 2010 water temperatures and Secchi depths.

**(a) Great Central Lake 2010**

| Depth (m) | 21-Apr-10 | 07-Jun-10 | 26-Jul-10 | 27-Sep-10 |
|---|---|---|---|---|
| 0 | 11.5 | 13.2 | 24.1 | 17.6 |
| 2 | 10.7 | 13.1 | 22.5 | 17.7 |
| 4 | 9.2 | 13.0 | 22.0 | 17.7 |
| 6 | 7.8 | 12.5 | 19.4 | 17.7 |
| 8 | 6.7 | 11.7 | 16.2 | 17.4 |
| 10 | 6.2 | 10.8 | 13.9 | 15.7 |
| 12 | 5.8 | 9.4 | 11.9 | 13.3 |
| 14 | 5.6 | 8.3 | 9.8 | 10.8 |
| 16 | 5.5 | 7.6 | 8.5 | 9.4 |
| 18 | 5.4 | 7.0 | 7.6 | 8.0 |
| 20 | 5.3 | 6.6 | 7.0 | 7.3 |
| 22 | 5.2 | 6.2 | 6.5 | 6.6 |
| **Secchi Depth (m)** | 8.0 | 8.9 | 11.7 | 7.6 |

**(b) Sproat Lake 2010**

| Depth (m) | 21-Apr-10 | 08-Jun-10 | 26-Jul-10 | 29-Sep-10 |
|---|---|---|---|---|
| 0 | 11.5 | 16.4 | 23.0 | 18.1 |
| 2 | 10.3 | 14.6 | 22.9 | 17.9 |
| 4 | 9.6 | 14.1 | 22.6 | 17.9 |
| 6 | 9.2 | 13.7 | 21.6 | 17.8 |
| 8 | 8.6 | 12.5 | 17.7 | 17.8 |
| 10 | 8.0 | 10.5 | 14.7 | 16.6 |
| 12 | 7.2 | 9.5 | 11.8 | 15.0 |
| 14 | 6.7 | 8.1 | 9.6 | 11.8 |
| 16 | 6.3 | 7.4 | 8.5 | 10.0 |
| 18 | 6.1 | 6.8 | 7.8 | 9.1 |
| 20 | 6.0 | 6.6 | 7.3 | 8.2 |
| 22 | 6.0 | 6.3 | 7.0 | 7.7 |
| **Secchi Depth (m)** | 8.3 | 11.3 | 16.6 | 14.2 |

(continued)

**(c) Henderson Lake 2010**

| Depth (m) | 27-Apr-10 | 14-Jun-10 | 27-Jul-10 | 29-Sep-10 |
|---|---|---|---|---|
| 0 | 9.1 | 14.0 | 20.2 | 16.8 |
| 2 | 9.0 | 13.9 | 20.2 | 16.3 |
| 4 | 8.8 | 14.0 | 20.1 | 16.1 |
| 6 | 8.6 | 13.9 | 19.8 | 16.0 |
| 8 | 8.3 | 13.8 | 19.5 | 16.0 |
| 10 | 8.2 | 13.0 | 19.0 | 16.0 |
| 12 | 7.9 | 12.6 | 17.6 | 15.9 |
| 14 | 7.6 | 11.7 | 14.6 | 15.6 |
| 16 | 7.4 | 9.8 | 11.0 | 14.5 |
| 18 | 7.2 | 8.9 | 9.5 | 12.5 |
| 20 | 7.1 | 8.7 | 9.0 | 11.0 |
| 22 | 7.0 | 8.2 | 8.5 | 9.6 |
| **Secchi Depth (m)** | 7.8 | 5.2 | 7.2 | 7.6 |

WATER CHEMISTRY: Estimates for TP were much higher in GC and Sproat lakes than they were in Henderson Lake (Table 19). The opposite was true for nitrogen and chlorophyll a, which were higher in Henderson Lake.

Table 19. Year 2010 water chemistry averaged over 2 stations in each lake.

| Sampling Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| **Great Central Lake 2010** | | | | | | | |
| 22-Apr-10 | 1, 3, 5 | 30.8 | 1.8 | 0.3 | 20 | 38.5 | 1.3 |
| 7-Jun-10 | 1, 3, 5 | 15.6 | 2.3 | 0.6 | 20 | 34.5 | 1.7 |
| 26-Jul-10 | 1, 3, 5 | 0.3 | 2.4 | 0.4 | 20 | 34.9 | 1.8 |
| 27-Sep-10 | 1, 3, 5 | 0.4 | 2.7 | 0.6 | 20 | 35.6 | 1.9 |
| **Sproat Lake 2010** | | | | | | | |
| 21-Apr-10 | 1, 3, 5 | 5.0 | 2.6 | 0.3 | 20 | 24.7 | 1.3 |
| 8-Jun-10 | 1, 3, 5 | 0.4 | 2.5 | 0.6 | 20 | 24.0 | 1.7 |
| 26-Jul-10 | 1, 3, 5 | 0.4 | 3.3 | 0.4 | 20 | 13.4 | 1.8 |
| 27-Sep-10 | 1, 3, 5 | 1.2 | 2.2 | 0.6 | 20 | 9.9 | 1.9 |
| **Henderson Lake 2010** | | | | | | | |
| 27-Apr-10 | 1, 3, 5 | 29.9 | <0.1 | 0.6 | 20 | 35.5 | <0.1 |
| 14-Jun-10 | 1, 3, 5 | 18.4 | 0.6 | 0.7 | 20 | 35.1 | <0.1 |
| 27-Jul-10 | 1, 3, 5 | 8.1 | <0.1 | 1.0 | 20 | 37.7 | <0.1 |
| 29-Sep-10 | 1, 3, 6 | 14.8 | 1.0 | 0.7 | 20 | 40.4 | <0.1 |

Water chemistry analyzed at Vancouver Island University showed that total alkalinity and calcium concentrations were highest in Sproat Lake, lower in GCL and lowest in Henderson Lake (Table 20). The low Ca concentrations observed in Henderson Lake may have negatively influenced chitin formation in *Daphnia*. Note the higher Na and Mg concentrations in Henderson Lake, which is meromictic.

Table 20. Year 2010 summary of average, water chemistry data analyzed at Vancouver Island University.

| Date | Total alkalinity (ppm $CaCO_3$) | Na (ppm) | Mg (ppm) | Ca (ppm) |
|---|---|---|---|---|
| **Great Central Lake** | | | | |
| 22-Apr-10 | 13.8 | 0.7 | 0.4 | 4.9 |
| 07-Jun-10 | 14.5 | 0.7 | 0.4 | 5.3 |
| 26-Jul-10 | 15.1 | 0.7 | 0.4 | 5.4 |
| 27-Sep-10 | 15.9 | 0.6 | 0.4 | 5.4 |
| 01-Dec-10 | 15.2 | 0.6 | 0.4 | 5.2 |
| **Sproat Lake** | | | | |
| 21-Apr-10 | 24.3 | 1.0 | 0.6 | 8.8 |
| 08-Jun-10 | 24.8 | 0.9 | 0.6 | 9.0 |
| 26-Jul-10 | 26.2 | 1.0 | 0.6 | 9.4 |
| 29-Sep-10 | 27.1 | 0.9 | 0.6 | 9.5 |
| 30-Nov-10 | 12.9 | 0.8 | 0.6 | 9.3 |
| **Henderson Lake** | | | | |
| 27-Apr-10 | 8.9 | 16.8 | 1.8 | 3.7 |
| 14-Jun-10 | 9.3 | 15.4 | 2.0 | 3.8 |
| 27-Jul-10 | 9.4 | 14.8 | 1.6 | 3.9 |
| 29-Sep-10 | 10.0 | 11.3 | 1.3 | 3.8 |

PHYTOPLANKTON BIOMASSES: Results were recorded from samples taken at 1, 3, and 5m (combined) (Table 21; Figure 15). Year 2010 phytoplankton biomass was highest in GCL and Henderson Lake, but most of that biomass comprised *Rhizosolenia* (now *Urosolenia*; Round et al. 1990), a large glass-like diatom that cannot be consumed by zooplankton. Sproat Lake had the lowest total phytoplankton biomass. All three lakes had approximately equal biomasses of edible algae.

Table 21. Year 2010 total and edible phytoplankton biovolume. Values are expressed as $mm^3$ / $m^3$.

**(a) Great Central Lake**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 22-Apr-10 | 1,3,5 | 0.00 | 9.59 | 2.31 | 0 | 41.75 | 1.78 | 0.00 | 5.87 | 0 | 98.67 | 159.97 |
| 07-Jun-10 | 1,3,5 | 0.09 | 30.38 | 8.83 | 0 | 72.87 | 6.30 | 4.81 | 4.09 | 0 | 579.97 | 707.34 |
| 26-Jul-10 | 1,3,5 | 0.29 | 41.14 | 1.27 | 0 | 89.15 | 0.30 | 2.87 | 16.18 | 0 | 73.67 | 224.87 |
| 27-Sep-10 | 1,3,5 | 3.91 | 66.78 | 3.89 | 0 | 50.79 | 0.49 | 3.18 | 23.25 | 0 | 19.01 | 171.30 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 22-Apr-10 | 1,3,5 | 0.00 | 9.59 | 2.31 | 0 | 41.54 | 1.78 | 0.00 | 5.87 | 0 | 11.76 | 72.85 |
| 07-Jun-10 | 1,3,5 | 0.00 | 26.80 | 8.83 | 0 | 67.19 | 6.30 | 4.81 | 2.38 | 0 | 45.63 | 161.94 |
| 26-Jul-10 | 1,3,5 | 0.00 | 41.14 | 1.27 | 0 | 86.02 | 0.30 | 2.87 | 12.80 | 0 | 9.58 | 153.98 |
| 27-Sep-10 | 1,3,5 | 1.95 | 54.25 | 3.89 | 0 | 49.69 | 0.49 | 3.18 | 9.78 | 0 | 2.23 | 125.46 |

**(b) Sproat Lake**

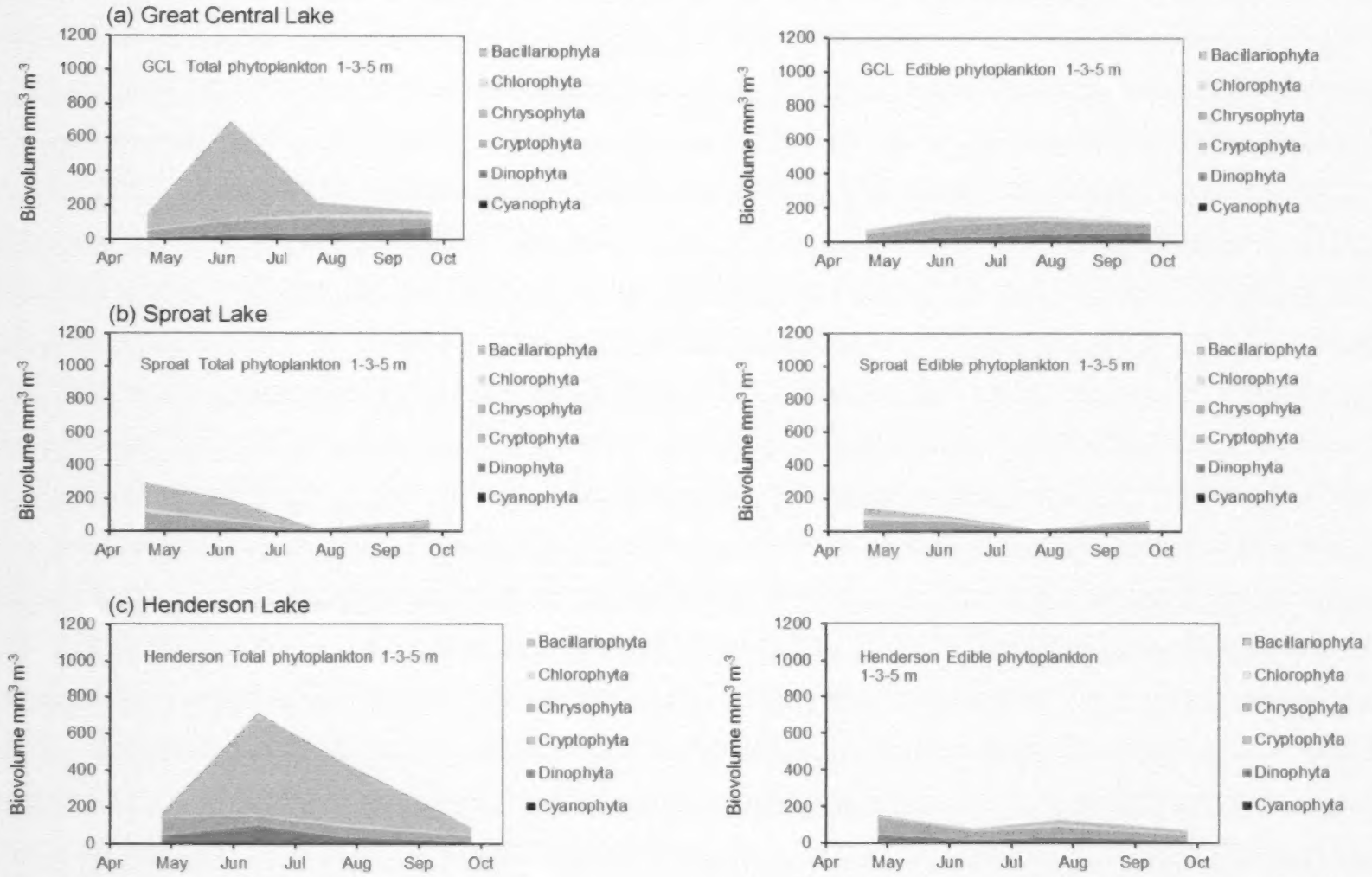
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 21-Apr-10 | 1,3,5 | 0 | 14 | 3 | 0 | 100 | 1 | 1 | 22 | 0 | 158 | 299 |
| 08-Jun-10 | 1,3,5 | 0 | 20 | 1 | 0 | 45 | 0 | 0 | 11 | 0 | 116 | 193 |
| 26-Jul-10 | 1,3,5 | 0 | 5 | 1 | 0 | 5 | 0 | 1 | 2 | 0 | 9 | 22 |
| 27-Sep-10 | 1,3,5 | 0 | 7 | 7 | 0 | 38 | 1 | 7 | 5 | 0 | 15 | 81 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 21-Apr-10 | 1,3,5 | 0 | 10 | 3 | 0 | 63 | 1 | 1 | 21 | 0 | 52 | 150 |
| 08-Jun-10 | 1,3,5 | 0 | 20 | 1 | 0 | 45 | 0 | 0 | 11 | 0 | 17 | 94 |
| 26-Jul-10 | 1,3,5 | 0 | 5 | 1 | 0 | 4 | 0 | 1 | 2 | 0 | 8 | 20 |
| 27-Sep-10 | 1,3,5 | 0 | 7 | 7 | 0 | 38 | 1 | 7 | 5 | 0 | 13 | 79 |

(continued)

**(b) Henderson Lake**

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Phytobiovolume** | | | | | | | | | | | | |
| 27-Apr-10 | 1,3,5 | 0 | 45 | 10 | 0 | 92 | 8 | 0 | 4 | 0 | 18 | 177 |
| 14-Jun-10 | 1,3,5 | 0 | 103 | 8 | 0 | 44 | 2 | 0 | 5 | 0 | 557 | 719 |
| 27-Jul-10 | 1,3,5 | 0 | 37 | 6 | 0 | 57 | 3 | 16 | 11 | 0 | 339 | 468 |
| 29-Sep-10 | 1,3,5 | 0 | 14 | 3 | 0 | 29 | 2 | 3 | 5 | 0 | 41 | 98 |
| **Edible Phytobiovolume** | | | | | | | | | | | | |
| 27-Apr-10 | 1,3,5 | 0 | 10 | 3 | 0 | 63 | 1 | 1 | 21 | 0 | 52 | 150 |
| 14-Jun-10 | 1,3,5 | 0 | 20 | 1 | 0 | 45 | 0 | 0 | 11 | 0 | 17 | 94 |
| 27-Jul-10 | 1,3,5 | 0 | 5 | 1 | 0 | 4 | 0 | 1 | 2 | 0 | 8 | 20 |
| 29-Sep-10 | 1,3,5 | 0 | 7 | 7 | 0 | 38 | 1 | 7 | 5 | 0 | 13 | 79 |

Figure 15. Year 2010 total and edible phytoplankton biomass as $mm^3\ m^{-3}$, which approximates $\mu g\ L^{-1}$ wet weight.



ZOOPLANKTON BIOMASSES: Biomasses were highest in Sproat > GCL > Henderson Lake (Table 22, Figure 16). Species diversity was about equal in all three lakes. Given that Henderson Lake edible phytoplankton biomasses were as high (Figure 16c) as they were in the other lakes (Figures 16a and b), it seems likely that zooplankton were limited by factors other than simple food availability. Perhaps low temperatures and higher turbidity (Table 18) were implicated. Note that *Daphnia* were common only in Sproat Lake.

Table 22. Year 2010 total zooplankton density per L and biomass as µg/L dry weight.

**(a) Great Central Lake 2010**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | *Ceriodaphnia* | Rotifers | Chironomids |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | | |
| 22-Apr-10 | 1.80 | 1.42 | 0.06 | 0.10 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.00 |
| 07-Jun-10 | 1.11 | 0.46 | 0.03 | 0.37 | 0.98 | 0.14 | 0.04 | 0.00 | 0.00 | 0.00 | 1.47 | 0.00 |
| 26-Jul-10 | 0.30 | 0.29 | 0.00 | 0.23 | 0.44 | 0.68 | 0.08 | 0.00 | 0.00 | 0.00 | 0.61 | 0.00 |
| **Biomass per L** | | | | | | | | | | | | |
| 22-Apr-10 | 4.60 | 0.20 | 0.22 | 0.95 | 0.11 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| 07-Jun-10 | 3.76 | 0.57 | 0.07 | 2.43 | 0.55 | 0.22 | 0.24 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 |
| 26-Jul-10 | 0.75 | 0.04 | 0.01 | 1.48 | 0.28 | 1.14 | 0.23 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 |

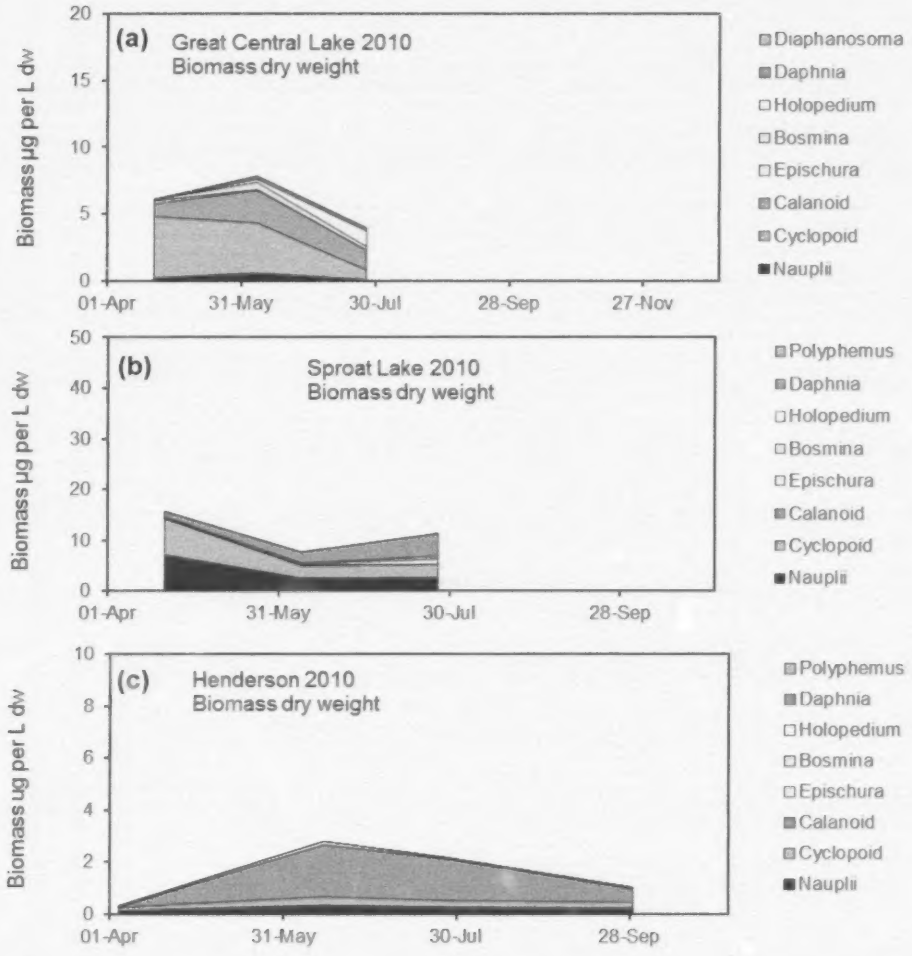
**(b) Sproat Lake**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | | |
| 21-Apr-10 | 1.55 | 0.97 | 0.01 | 0.00 | 0.11 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.42 | 0.00 |
| 08-Jun-10 | 0.84 | 1.87 | 0.01 | 0.00 | 0.28 | 0.01 | 0.68 | 0.00 | 0.00 | 0.00 | 0.66 | 0.00 |
| 26-Jul-10 | 0.72 | 1.97 | 0.00 | 0.00 | 1.58 | 0.30 | 1.57 | 0.01 | 0.00 | 0.00 | 3.53 | 0.00 |
| **Biomass per L** | | | | | | | | | | | | |
| 21-Apr-10 | 7.15 | 0.13 | 0.22 | 0.04 | 0.11 | 0.00 | 1.01 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| 08-Jun-10 | 2.50 | 0.27 | 0.19 | 0.01 | 0.24 | 0.02 | 2.23 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 |
| 26-Jul-10 | 2.59 | 0.28 | 0.05 | 0.00 | 1.13 | 0.51 | 4.46 | 0.01 | 0.00 | 0.00 | 0.50 | 0.00 |

**(c) Henderson Lake**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifers | Chironomids |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 04-Apr-10 | 0.06 | 0.50 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14-Jun-10 | 0.08 | 0.52 | 0.00 | 0.38 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27-Jul-10 | 0.08 | 0.66 | 0.00 | 0.78 | 0.15 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 29-Sep-10 | 0.08 | 0.52 | 0.00 | 0.17 | 0.17 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 04-Apr-10 | 0.13 | 0.07 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14-Jun-10 | 0.33 | 0.07 | 0.00 | 1.99 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27-Jul-10 | 0.26 | 0.09 | 0.00 | 1.60 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29-Sep-10 | 0.23 | 0.07 | 0.00 | 0.53 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |

Figure 16. Year 2010 zooplankton biomasses as µg $L^{-1}$ dry weight. Note differences in the y-axis. Samples were metered for net efficiency.



GCL day and night 25m vertical hauls collected on April 22, 2010 (Table 23), suggested that with the exception of *Skistodiaptomus oregonensis* (Table 24), densities over a haul-depth of 25 m did not change with time of day. This result does not agree with a more complex comparison of day versus night and 25 versus 50 m vertical haul samples conducted Sproat Lake on 09 June 2009. That experiment showed that the highest zooplankton densities were obtained during the night and at 25 m depth. Two-way ANOVA of the 2009 data showed significant day versus night and 25 versus 50 m effects for *Bosmina*, *Cyclops*, and *Daphnia*. Nauplii were significant only for day-night, but not depth. A possible explanation for this discrepancy is that the 2010 experiment was conducted in April before the lake stratified and the 2009 experiment was conducted in June after thermal stratification.

Table 23. Day and Night 25 m vertical hauls collected on April 22, 2010 at Great Central Lake. The data represent zooplankton total densities collected in each net haul.

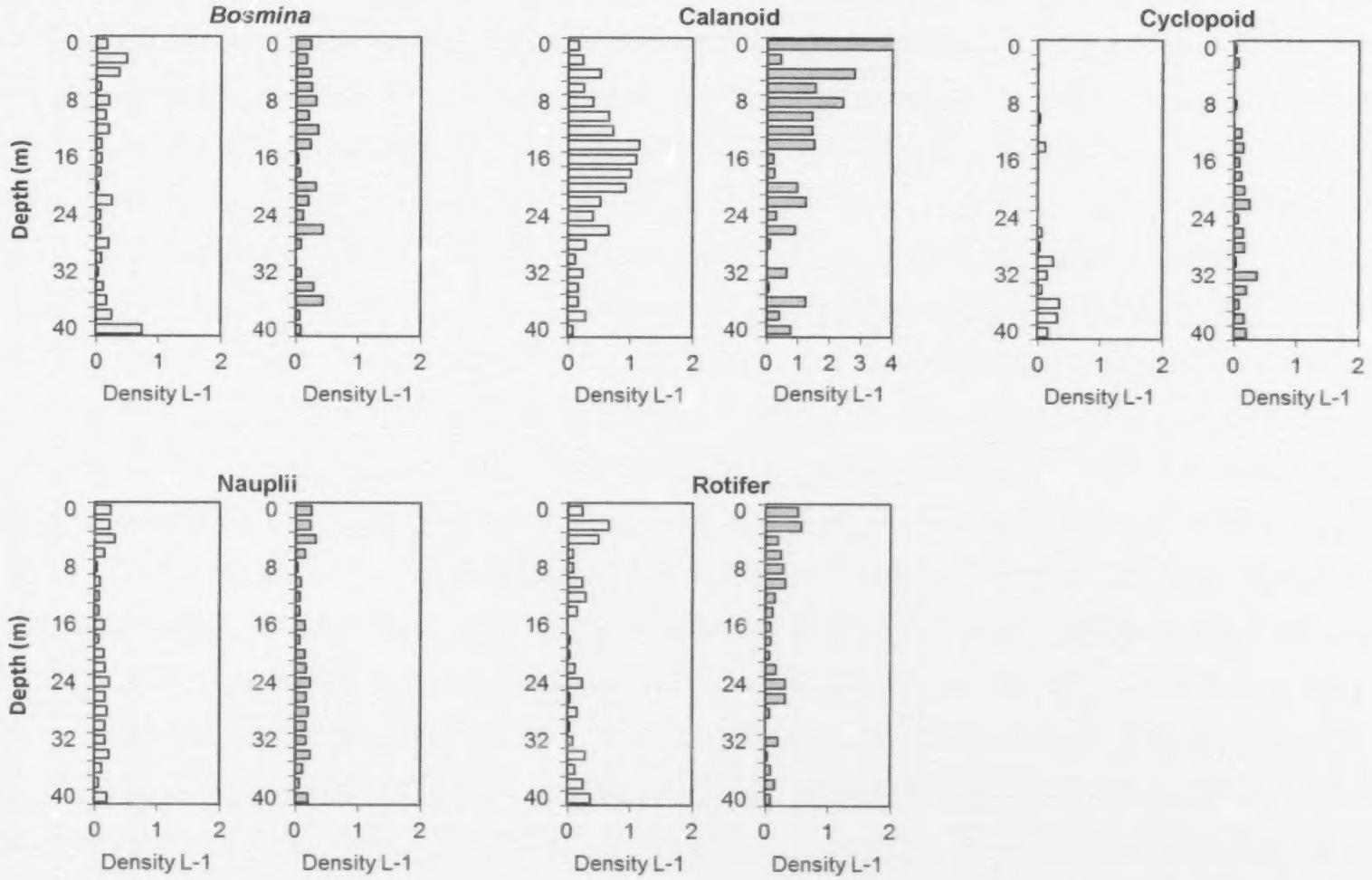
| Replicate | Nauplii | | Bosmina | | Cyclopoid | | Calanoid | | Epischura | | Holopedium | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Day | Night | Day | Night | Day | Night | Day | Night | Day | Night | Day | Night |
| 1 | 22187 | 19456 | 1365 | 640 | 30549 | 27904 | 341 | 2048 | 341 | 0 | 0 | 0 |
| 2 | 12885 | 9728 | 512 | 704 | 11093 | 10240 | 171 | 1408 | 171 | 192 | 171 | 64 |
| 3 | 13824 | 11093 | 1109 | 939 | 11349 | 14251 | 0 | 512 | 1877 | 1792 | 85 | 85 |
| 4 | 13824 | 12160 | 939 | 2176 | 19541 | 24320 | 85 | 768 | 768 | 1152 | 85 | 0 |
| mean | 15680 | 13109 | 981 | 1115 | 18133 | 19179 | 149 | 1184 | 789 | 784 | 85 | 37 |

Table 24. P-values for species-specific single factor Analyses of Variance testing the hypothesis that there was no difference between day and night densities for five taxonomic groups of zooplankton from Great Central Lake collected on April 22, 2010. Data are shown in Table 23.

| Taxa | P-value |
|---|---|
| Nauplii | 0.43 |
| Bosmina | 0.75 |
| Cyclops | 0.87 |
| Calanoid | 0.025 |
| Holopedium | 0.28 |

SCHINDLER TRAP SAMPLING

Figure 17. June 10, 2010 Henderson Lake zooplankton depth distributions based on Schindler Trap samples. The Schindler trap sampled 30 L. Yellow is day and black is night.



FISH DENSITIES, LENGTHS, AND WEIGHTS: Results are summarized in Table 25. Weights have been corrected for shrinkage due to the ethanol used as a preservative. Based on smolt data (Table 25), Henderson Lake sockeye grew more slowly that they did in Sproat Lake>GCL. 95 % confidence intervals around the means of fish abundance are also provided. The mean of one or more winter survey values (Nov-Feb) is considered to be useable as a spring smolt production estimate when 95% confidence intervals suggest multiple estimates be treated as replicates. If winter survey values differ significantly, then the latest survey value is considered to represent the best annual estimate of smolt production.

Table 25. Year 2010, mean limnetic fish densities, lengths, and weights and, smolt lengths and weights. Weights have been corrected for shrinking due to the effects of the ethanol used as a preservative. SB = stickleback.

| Sampling Date | Total Limnetic Fish Number | Limnetic Fish Density per ha | Conf. Intervals (%) | Sockeye Density per ha | SB Density per ha | Sockeye Mean Length (mm) | Sockeye Mean Weight (g) | Sockeye Sample Size (n) | SB mean Length (mm) | SB mean Weight (g) | Sample Size (n) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | | | | |
| 01-Jun-10 | 10,063,784 | 2,000 | 33 | 2,000 | 0 | 33 | 0.3 | 100 | | | |
| 30-Aug-10 | 24,557,303 | 4,829 | 39 | 4,829 | 0 | 43 | 0.7 | 38 | | | |
| 01-Dec-10 | 11,015,426 | 2,166 | 16 | 2,166 | 0 | | | | | | |
| 08-May-11 | Smolts | | | | | 65 | 2.8 | 102 | | | |
| **(b) Sproat Lake** | | | | | | | | | | | |
| 10-Jun-10 | nd | | | | | 35 | 0.4 | 145 | | | |
| 24-Aug-10 | 8,166,458 | 2,163 | 32 | 2,163 | 0 | | | | | | |
| 30-Nov-10 | 14,526,189 | 3,848 | 24 | 3,848 | 0 | 66 | 2.7 | 64 | | | |
| 28-Apr-11 | Smolts | | | | | 79 | 5.1 | 204 | | | |
| 08-May-11 | Smolts | | | | | 75 | 4.8 | 98 | | | |
| **(c) Henderson Lake** | | | | | | | | | | | |
| 16-Jun-10 | nd | | | | | 34 | 0.3 | | 48 | 0.94 | 2 |
| 30-Aug-10 | 1,921,887 | 1,244 | 23 | 670 | 574 | 39 | 0.9 | 38 | nd | nd | |
| 31-Jan-11 | 1,189,596 | 770 | 22 | 715 | 55 | 51 | 1.0 | 15 | 37 | 0.43 | 1 |
| 26-Apr-11 | Smolts | | | | | 55 | 1.6 | 178 | | | |

## YEAR 2011: GREAT CENTRAL, SPROAT, AND HENDERSON LAKES DATA SUMMARY

SAMPLING SCHEDULE FOR 2011

Table 26. Samples collected during 2011. x = sample collected. N-25 = zooplankton sampled at night 0-25 m. D-50 = zooplankton sampled in the day 0-50 m. 0 = data not collected. TR = trip report available.

| Date surveyed | DFO chemistry | VIU chemistry | Temperature | Oxygen | Secchi | Phytoplankton 1,3,5 | Zooplankton | Rigosha Metered | Acoustic Records | Biosampling fish | Smolts (2012) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2011** | | | | | | | | | | | | |
| 30-May-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 4-Jul-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 22-Aug-11 | x | x | x | 0 | x | x | N-25 | | x | x | | TR |
| 3-Oct-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 22-Nov-11 | | | | | | | | | x | x | | TR |
| 17-Apr-12 | | | | | | | | | | | x | TR |
| 25-Apr-12 | | | | | | | | | | | x | TR |
| **Sproat Lake 2011** | | | | | | | | | | | | |
| 30-May-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 04-Jul-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 16-Aug-11 | x | x | x | x | x | x | D-50 | x | x | | | TR |
| 27-Sep-11 | | | | | | | x | | | | | |
| 04-Oct-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 21-Nov-11 | | | | | | | | | x | x | | TR |
| 23-Apr-12 | | | | | | | | | | | x | TR |
| **Henderson Lake 2011** | | | | | | | | | | | | |
| 31-May-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 05-Jul-11 | x | x | x | x | x | x | D-50 | x | | | | TR |
| 27-Jul-11 | | | | | | | x | | | | | TR |
| 24-Aug-11 | x | x | x | x | x | x | D-50 | x | x | x | | TR |
| 29-Sep-11 | | | | | | | x | | | | | TR |
| 04-Oct-11 | | x | x | x | x | x | D-50 | x | | | | TR |
| 05-Mar-12 | | | | | | | | | | | x | TR |
| 14-Mar-12 | | | | | | | | | | | x | TR |
| 04-May-12 | | | | | | | | | | | x | TR |

TEMPERATURE AND SECCHI DEPTHS: Results from GCL and Sproat were similar in 2011 (Table 27). Henderson Lake was slightly cooler in the spring but warmed in the early summer and the Henderson Lake Secchi depths were slightly more shallow suggesting higher turbidity. Both of these characteristics would be expected to reduce productive capacity for juvenile sockeye salmon.

Table 27. Year 2011 water temperatures and Secchi depths.

**(a) Great Central Lake 2011**

| Depth (m) | Temperature (°C) | | | |
|---|---|---|---|---|
| | 30-May-11 | 04-Jul-11 | 22-Aug-11 | 04-Oct-11 |
| 0 | 12.5 | 17.3 | 21.0 | 15.3 |
| 2 | 12.0 | 15.8 | 20.9 | 15.4 |
| 4 | 11.8 | 15.5 | 20.1 | 15.4 |
| 6 | 11.7 | 15.1 | 19.0 | 15.4 |
| 8 | 11.0 | 14.7 | 15.3 | 15.4 |
| 10 | 10.2 | 11.7 | 13.1 | 14.7 |
| 12 | 9.4 | 9.4 | 12.1 | 12.2 |
| 14 | 8.2 | 8.1 | 10.3 | 10.3 |
| 16 | 7.5 | 7.3 | 8.9 | 8.7 |
| 18 | 6.7 | 6.7 | 8.1 | 7.3 |
| 20 | 6.2 | 6.3 | 7.3 | 6.5 |
| 22 | 5.6 | 5.9 | 6.7 | 6.1 |
| Secchi Depth (m) | 11.4 | 12.5 | 8.7 | 7.9 |

**(b) Sproat Lake 2011**

| Depth (m) | Temperature (°C) | | | |
|---|---|---|---|---|
| | 30-May-11 | 05-Jul-11 | 16-Aug-11 | 04-Oct-11 |
| 0 | 12.6 | 16.6 | 20.7 | 15.9 |
| 2 | 12.3 | 16.4 | 19.7 | 16.0 |
| 4 | 12.0 | 16.2 | 19.4 | 16.0 |
| 6 | 11.7 | 16.1 | 19.3 | 16.0 |
| 8 | 10.9 | 14.8 | 18.3 | 16.0 |
| 10 | 9.9 | 11.8 | 14.2 | 14.7 |
| 12 | 8.1 | 9.7 | 11.5 | 13.6 |
| 14 | 7.2 | 8.5 | 9.4 | 11.6 |
| 16 | 6.6 | 7.5 | 8.2 | 10.1 |
| 18 | 6.2 | 6.9 | 7.5 | 8.8 |
| 20 | 6.0 | 6.5 | 7.0 | 7.8 |
| 22 | 5.7 | 6.2 | 6.5 | 7.2 |
| Secchi Depth (m) | 8.9 | 12.6 | 15.5 | 10.2 |

(continued)

**(c) Henderson Lake 2011**

| Depth (m) | Temperature (°C) | | | |
|---|---|---|---|---|
| | 31-May-11 | 05-Jul-11 | 24-Aug-12 | 06-Oct-11 |
| 0 | 9.1 | 14.0 | 20.2 | 16.8 |
| 2 | 9.0 | 13.9 | 20.2 | 16.3 |
| 4 | 8.8 | 14.0 | 20.1 | 16.1 |
| 6 | 8.6 | 13.9 | 19.8 | 16.0 |
| 8 | 8.3 | 13.8 | 19.5 | 16.0 |
| 10 | 8.2 | 13.0 | 19.0 | 16.0 |
| 12 | 7.9 | 12.6 | 17.6 | 15.9 |
| 14 | 7.6 | 11.7 | 14.6 | 15.6 |
| 16 | 7.4 | 9.8 | 11.0 | 14.5 |
| 18 | 7.2 | 8.9 | 9.5 | 12.5 |
| 20 | 7.1 | 8.7 | 9.0 | 11.0 |
| 22 | 7.0 | 8.2 | 8.5 | 9.6 |
| **Secchi Depth (m)** | 8.6 | 11.3 | 8.6 | 9.0 |

WATER CHEMISTRY: Estimates for TP were much higher in GCL and Sproat Lake than they were in Henderson Lake (Table 28). The opposite was true for nitrogen and chlorophyll a, which were higher in Henderson Lake. Note also that nitrogen was high in the GCL hypolimnion, suggesting a nitrogen excess in the amount of fertilizer added later in the summer.

Table 28. Year 2011 water chemistry averaged over 2 stations in each lake.

| Date | Depth (m) | Nitrate ($\mu g\ L^{-1}$) | TP ($\mu g\ L^{-1}$) | Chlorophyll ($\mu g\ L^{-1}$) | Depth (m) | Nitrate ($\mu g\ L^{-1}$) | TP ($\mu g\ L^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Great Central Lake 2011** | | | | | | | |
| 30-May-11 | 1, 3, 5 | 26.1 | 0.8 | 0.2 | 25 | 37.9 | 1.8 |
| 4-Jul-11 | 1, 3, 5 | 12.2 | 1.3 | 0.5 | 25 | 34.7 | 1.4 |
| 22-Aug-11 | 1, 3, 5 | 1.2 | 1.1 | 0.4 | 25 | 34.5 | 1.7 |
| 3-Oct-11 | 1, 3, 5 | 2.9 | 2.1 | 0.5 | 25 | 30.9 | 1.7 |
| **Sproat Lake 2011** | | | | | | | |
| 30-May-11 | 1, 3, 5 | 4.1 | 2.1 | 0.4 | 25 | 32.9 | 2.1 |
| 4-Jul-11 | 1, 3, 5 | 0.7 | 1.6 | 0.3 | 25 | 22.9 | 2.6 |
| 16-Aug-11 | 1, 3, 5 | 0.3 | 1.4 | 0.1 | 25 | 8.1 | 2.3 |
| 4-Oct-11 | 1, 3, 5 | 0.4 | 2.1 | 0.6 | 25 | 3.4 | 2.6 |
| **Henderson Lake 2011** | | | | | | | |
| 31-May-11 | 1, 3, 5 | 23.7 | <0.1 | 0.4 | 25 | 40.1 | <0.1 |
| 5-Jul-11 | 1, 3, 5 | 15.2 | <0.1 | 0.8 | 25 | 43.4 | <0.1 |
| 24-Aug-11 | 1, 3, 5 | 9.3 | <0.1 | 0.8 | 25 | 44.5 | <0.1 |
| 4-Oct-11 | 1, 3, 6 | 16.3 | <0.1 | 0.6 | 25 | 42.5 | <0.1 |

Water chemistry analyzed at Vancouver Island University showed that total alkalinity and calcium concentrations were highest in Sproat Lake, lower in GCL, and lowest in Henderson Lake (Table 29). The low Ca concentrations observed in Henderson Lake may have negatively influenced chitin formation in *Daphnia*. Note the higher Na and Mg concentrations in Henderson Lake.

Table 29. Year 2011 summary of average, water chemistry data analyzed at Vancouver Island University.

| Sampling Date | Total alkalinity (ppm CaCO3) | Na (ppm) | Mg (ppm) | Ca (ppm) |
|---|---|---|---|---|
| **Great Central Lake** | | | | |
| 30-May-11 | 16.2 | 0.7 | 0.4 | 5.1 |
| 04-Jul-11 | 17.0 | 0.7 | 0.4 | 5.5 |
| 22-Aug-11 | 18.2 | 0.7 | 0.4 | 5.6 |
| 03-Oct-11 | 17.5 | 0.7 | 0.4 | 5.5 |
| **Sproat Lake** | | | | |
| 30-May-11 | 30.4 | 1.0 | 0.7 | 9.5 |
| 04-Jul-11 | 30.7 | 1.0 | 0.7 | 9.9 |
| 16-Aug-11 | 32.2 | 1.0 | 0.7 | 10.1 |
| 04-Oct-11 | 30.1 | 1.0 | 0.7 | 9.8 |
| **Henderson Lake** | | | | |
| 31-May-11 | 9.9 | 16.9 | 2.3 | 3.8 |
| 05-Jul-11 | 10.7 | 15.0 | 2.2 | 4.2 |
| 24-Aug-11 | 11.8 | 14.7 | 2.1 | 4.3 |
| 04-Oct-11 | 11.1 | 12.0 | 1.7 | 4.0 |

PHYTOPLANKTON BIOMASSES: Results were recorded from samples taken at 1,3, and 5m (combined; Table 30; Figures 18 a, b, and c). Year 2011 phytoplankton biomass was highest in GCL and Henderson Lake, but most of that biomass comprised *Rhizosolenia* (now *Urosolenia*; Round et al. 1990), a large glass-like diatom that cannot be consumed by zooplankton. Sproat Lake had the lowest total phytoplankton biomass. Concentrations of edible algae were highest in Henderson Lake, followed by Sproat and GCL.

Table 30. Year 2011 total and edible phytoplankton biovolume. Values are expressed as $mm^3$ / $m^3$.

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | | | | | |
| Total Phytobiovolume | | | | | | | | | | | | |
| 30-May-11 | 1,3,5 | 0 | 13 | 1 | 0 | 4 | 1 | 0 | 7 | 0 | 1062 | 1088 |
| 04-Jul-11 | 1,3,5 | 0 | 28 | 14 | 0 | 30 | 0 | 0 | 5 | 0 | 1154 | 1232 |
| 22-Aug-11 | 1,3,5 | 0 | 20 | 0 | 0 | 46 | 0 | 1 | 8 | 0 | 34 | 109 |
| 03-Oct-11 | 1,3,5 | 2 | 24 | 8 | 0 | 19 | 0 | 4 | 14 | 0 | 97 | 169 |
| Edible Phytobiovolume | | | | | | | | | | | | |
| 30-May-11 | 1,3,5 | 0 | 13 | 1 | 0 | 3 | 1 | 0 | 5 | 0 | 11 | 35 |
| 04-Jul-11 | 1,3,5 | 0 | 28 | 14 | 0 | 30 | 0 | 0 | 5 | 0 | 13 | 91 |
| 22-Aug-11 | 1,3,5 | 0 | 20 | 0 | 0 | 45 | 0 | 1 | 7 | 0 | 2 | 76 |
| 03-Oct-11 | 1,3,5 | 0 | 2 | 8 | 0 | 12 | 0 | 4 | 12 | 0 | 10 | 48 |
| **(b) Sproat Lake** | | | | | | | | | | | | |
| Total Phytobiovolume | | | | | | | | | | | | |
| 30-May-11 | 1,3,5 | 0 | 19 | 5 | 0 | 16 | 1 | 1 | 6 | 0 | 533 | 582 |
| 04-Jul-11 | 1,3,5 | 0 | 42 | 1 | 0 | 28 | 1 | 8 | 4 | 0 | 153 | 237 |
| 16-Aug-11 | 1,3,5 | 0 | 5 | 2 | 0 | 12 | 0 | 4 | 1 | 0 | 3 | 28 |
| 04-Oct-11 | 1,3,5 | 0 | 31 | 4 | 0 | 66 | 2 | 14 | 3 | 0 | 14 | 134 |
| Edible Phytobiovolume | | | | | | | | | | | | |
| 30-May-11 | 1,3,5 | 0 | 8 | 5 | 0 | 9 | 1 | 1 | 6 | 0 | 41 | 72 |
| 04-Jul-11 | 1,3,5 | 0 | 42 | 1 | 0 | 21 | 1 | 8 | 4 | 0 | 138 | 214 |
| 16-Aug-11 | 1,3,5 | 0 | 2 | 2 | 0 | 12 | 0 | 4 | 1 | 0 | 2 | 25 |
| 04-Oct-11 | 1,3,5 | 0 | 4 | 4 | 0 | 66 | 2 | 14 | 3 | 0 | 6 | 98 |

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(c) Henderson Lake** | | | | | | | | | | | | |
| Total Phytobiovolume | | | | | | | | | | | | |
| 31-May-11 | 1,3,5 | 0 | 72 | 14 | 0 | 34 | 2 | 0 | 3 | 0 | 163 | 289 |
| 03-Jul-11 | 1,3,5 | 0 | 25 | 3 | 0 | 9 | 2 | 4 | 4 | 0 | 1352 | 1401 |
| 22-Aug-11 | 1,3,5 | 0 | 79 | 4 | 0 | 177 | 6 | 3 | 8 | 0 | 120 | 397 |
| 04-Oct-11 | 1,3,5 | 0 | 22 | 14 | 0 | 61 | 4 | 0 | 5 | 0 | 193 | 300 |
| Edible Phytobiovolume | | | | | | | | | | | | |
| 31-May-11 | 1,3,5 | 0 | 72 | 14 | 0 | 30 | 2 | 0 | 3 | 0 | 7 | 130 |
| 03-Jul-11 | 1,3,5 | 0 | 25 | 3 | 0 | 8 | 2 | 4 | 4 | 0 | 10 | 57 |
| 22-Aug-11 | 1,3,5 | 0 | 79 | 4 | 0 | 175 | 6 | 3 | 8 | 0 | 33 | 308 |
| 04-Oct-11 | 1,3,5 | 0 | 12 | 14 | 0 | 56 | 4 | 0 | 5 | 0 | 6 | 98 |

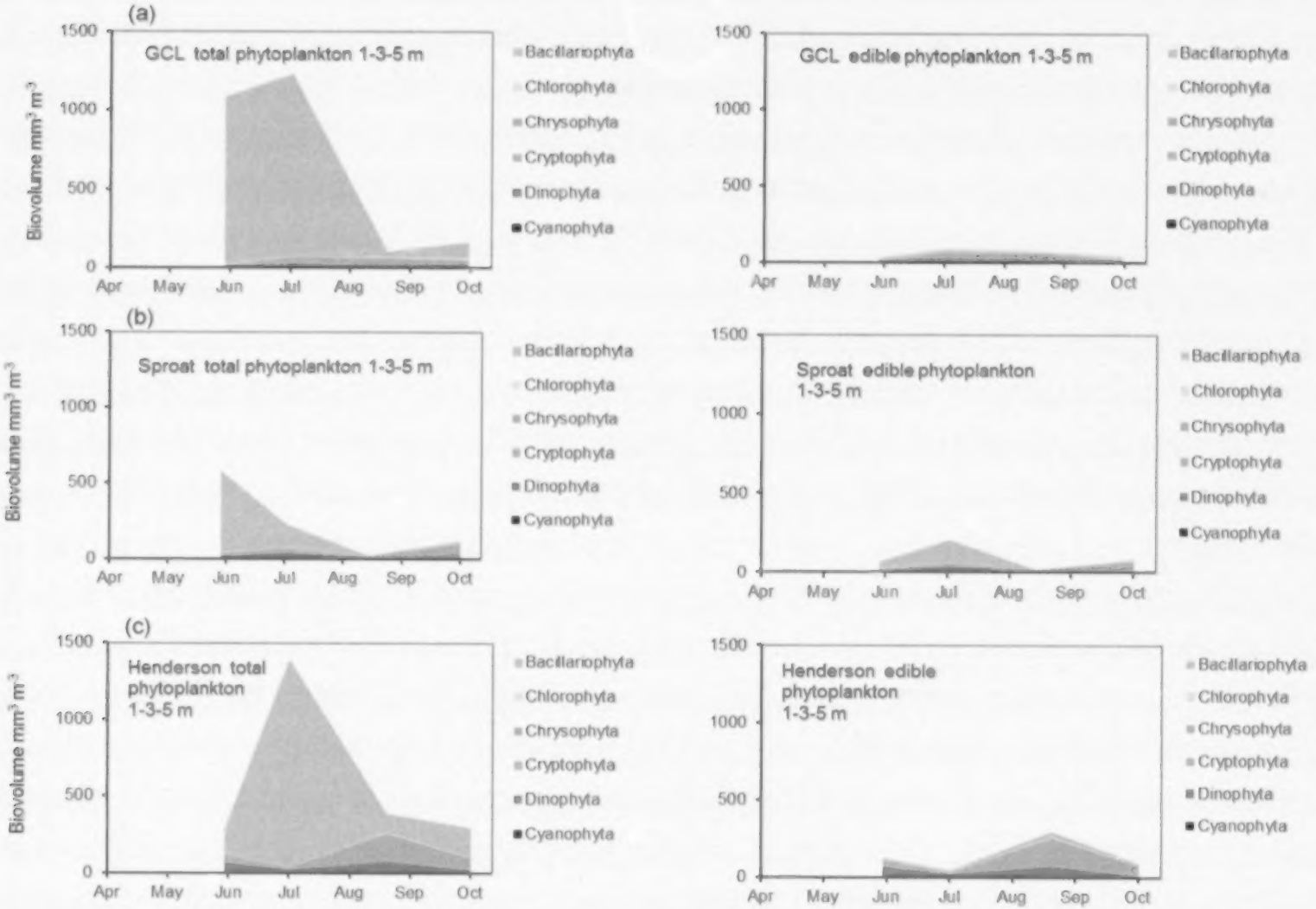



Figure 18. Year 2011 total and edible phytoplankton biomass as $mm^3\ m^{-3}$, which approximates $\mu g\ L^{-1}$ wet weight.

ZOOPLANKTON BIOMASSES: Biomasses were highest in Sproat > GCL > Henderson Lake (Table 31; Figure 19). Species diversity was about equal in all three lakes. Given that Henderson Lake edible phytoplankton biomasses were higher (Figure 19c) than they were in the other lakes (Figures 19a and b), it seems likely that zooplankton were limited by factors other than simple food availability. Perhaps low temperatures and higher turbidity (Table 27) were implicated. Note that *Daphnia* were common only in Sproat Lake.

Table 31. Year 2011 total zooplankton density per L and biomass as µg/L dry weight.

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | *Ceriodaphnia* | Rotifers | Chironomid | *Sida* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | | | | | | |
| **Density per L** | | | | | | | | | | | | | |
| 30-May-11 | 2.22 | 0.68 | 0.01 | 0.09 | 0.18 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.40 | 0.00 | 0.00 |
| 05-Jul-11 | 1.06 | 0.69 | 0.00 | 0.02 | 0.29 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.89 | 0.00 | 0.00 |
| 03-Oct-11 | 0.20 | 0.47 | 0.00 | 0.20 | 0.92 | 0.78 | 0.00 | 0.00 | 0.08 | 0.00 | 0.45 | 0.00 | 0.00 |
| **Biomass per L** | | | | | | | | | | | | | |
| 30-May-11 | 6.13 | 0.10 | 0.09 | 0.89 | 0.08 | 0.17 | 0.38 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| 05-Jul-11 | 3.05 | 0.10 | 0.04 | 0.20 | 0.17 | 0.03 | 0.05 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 |
| 03-Oct-11 | 0.88 | 0.11 | 0.04 | 1.33 | 0.96 | 2.86 | 0.02 | 0.00 | 0.30 | 0.00 | 0.04 | 0.00 | 0.00 |
| **(b) Sproat Lake** | | | | | | | | | | | | | |
| **Density per L** | | | | | | | | | | | | | |
| 30-May-11 | 4.11 | 3.77 | 0.01 | 0.00 | 0.58 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 04-Jul-11 | 5.13 | 12.73 | 0.00 | 0.00 | 0.66 | 0.03 | 0.58 | 0.00 | 0.00 | 0.00 | 2.38 | 0.00 | 0.00 |
| 16-Aug-11 | 1.89 | 7.57 | 0.00 | 0.00 | 2.20 | 0.09 | 0.42 | 0.00 | 0.00 | 0.00 | 2.23 | 0.00 | 0.00 |
| 04-Oct-11 | 0.31 | 6.10 | 0.01 | 0.00 | 1.20 | 0.22 | 0.59 | 0.00 | 0.00 | 0.00 | 10.33 | 0.00 | 0.00 |
| **Biomass per L** | | | | | | | | | | | | | |
| 30-May-11 | 16.84 | 0.67 | 0.44 | 0.01 | 0.49 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.09 | 0.01 | 0.00 |
| 04-Jul-11 | 12.42 | 1.82 | 0.06 | 0.01 | 0.39 | 0.04 | 1.63 | 0.00 | 0.00 | 0.00 | 0.17 | 0.01 | 0.00 |
| 16-Aug-11 | 3.10 | 0.86 | 0.04 | 0.00 | 0.96 | 0.09 | 0.97 | 0.01 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 |
| 04-Oct-11 | 0.91 | 0.87 | 0.11 | 0.01 | 0.78 | 0.32 | 1.41 | 0.00 | 0.00 | 0.00 | 0.74 | 0.00 | 0.00 |

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifers | Chironomid |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **(c) Henderson Lake** | | | | | | | | | | | |
| **Density per L** | | | | | | | | | | | |
| 31-May-11 | 0.11 | 0.59 | 0.00 | 0.15 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 05-Jul-11 | 0.03 | 0.53 | 0.00 | 0.12 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24-Aug-11 | 0.22 | 0.39 | 0.00 | 0.07 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 05-Oct-11 | 0.05 | 0.12 | 0.00 | 0.02 | 0.30 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 31-May-11 | 0.29 | 0.08 | 0.00 | 1.04 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 05-Jul-11 | 0.13 | 0.08 | 0.00 | 0.73 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24-Aug-11 | 0.57 | 0.06 | 0.00 | 0.18 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 05-Oct-11 | 0.13 | 0.02 | 0.00 | 0.14 | 0.09 | 0.00 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 |

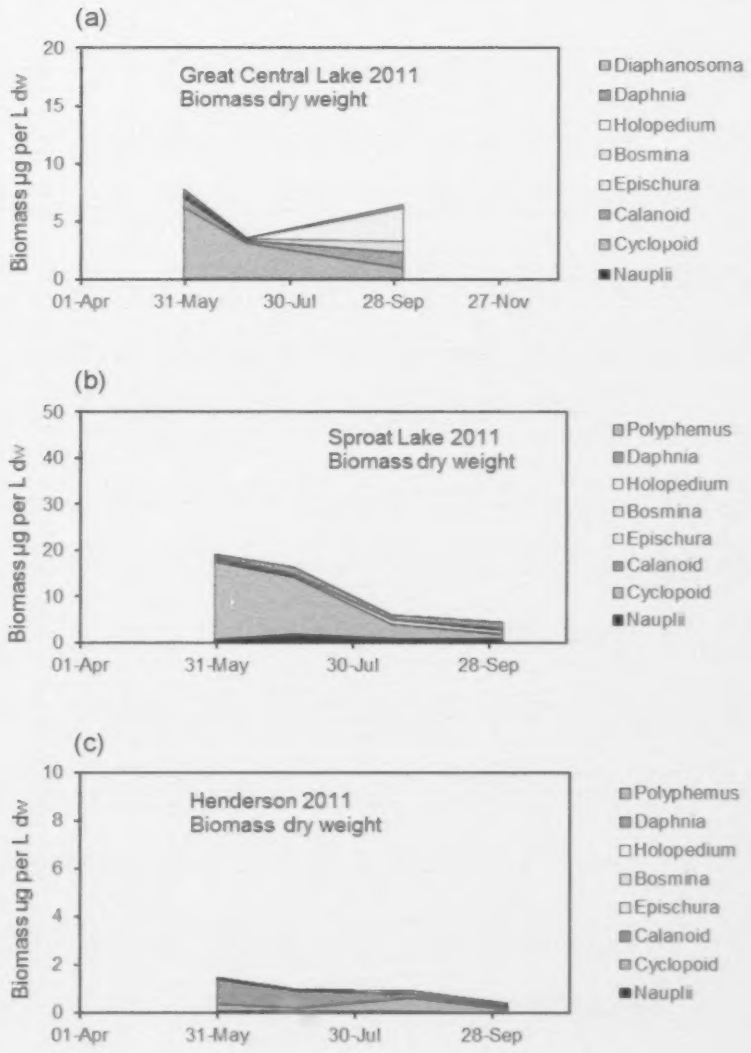



Figure 19. Year 2011 zooplankton biomasses as µg L-1 dry weight. Note differences in the y-axis. Samples were metered for net efficiency.

FISH DENSITIES, LENGTHS AND WEIGHTS: Results are summarized in Table 32. Weights have been corrected for shrinkage due to the effects of the ethanol used as a preservative. Henderson Lake sockeye grew more slowly that they did in Sproat Lake > GCL. Smolt lengths and weights were collected in the spring of 2012. Note the substantial increase of lengths and weights of smolts when compared to the trawl-based fry samples. 95 % confidence intervals around the means of fish abundance are also provided. The mean of one or more winter survey values (Nov-Feb) is considered to be useable as a spring smolt production estimate when 95% confidence intervals suggest multiple estimates be treated as replicates. If winter survey values differ significantly, then the latest survey value is considered to represent the best annual estimate of smolt production.

Table 32. Year 2011 fish densities, lengths, and weights for Great Central, Sproat, and Henderson Lakes. SB = stickleback.

| Sampling Date | Total Limnetic Fish Density | Limnetic Fish Density per ha | Conf. Intervals (%) | Sockeye Density per ha | SB Density per ha | Sockeye Mean Length (mm) | Sockeye Mean Weight (g) | Sample Size (n) |
|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | |
| 22-Aug-11 | 45,991,451 | 9,045 | 73 | 9,045 | 0 | 37 | 0.4 | 332 |
| 22-Nov-11 | 16,267,230 | 3,199 | 17 | 3,199 | 0 | 49 | 1.3 | 196 |
| 17-Apr-12 | Smolts | | | | | 76 | 3.8 | 100 |
| 25-Apr-12 | Smolts | | | | | 73 | 3.2 | 100 |
| **(b) Sproat Lake** | | | | | | | | |
| 16-Aug-11 | 16,661,391 | 4,414 | 34 | 4,414 | 0 | | | no trawl |
| 21-Nov-11 | 13,444,391 | 3,561 | 9 | 3,561 | 0 | 62 | 2.2 | 223 |
| 23-Apr-12 | Smolts | | | | | 73 | 2.9 | 35 |
| **(c) Henderson Lake** | | | | | | | | |
| 24-Aug-11 | 10,975,946 | 7,104 | 20 | 7,104 | 0 | 36 | 0.5 | 447 |
| 05-Mar-12 | 280,607 | 182 | 27 | 154 | 28 | 30 | 0.2 | 100 |
| 14-Mar-12 | Smolts | | | | | 44 | 0.7 | 3 |
| 04-May-12 | Smolts | | | | | 44 | 0.6 | 2 |

## YEAR 2012: GREAT CENTRAL, SPROAT, AND HENDERSON LAKES DATA SUMMARY

SAMPLING SCHEDULE FOR 2012

Table 33. Samples collected during 2012. x = sample collected. D-50 = zooplankton sampled in the day 0-50 m. 0 = data not collected. TR = trip report available.

| Date surveyed | DFO chemistry | VIU chemistry | Temperature | Oxygen | Secchi | Phytoplankton 1,3,5 | Zooplankton | Rigosha | Acoustic Records | Biosampling fish | Smolts (2013) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2012** | | | | | | | | | | | | |
| 04-Jun-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 11-Jun-12 | | | | | | | | | x | x | | TR |
| 16-Jul-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 13-Aug-12 | | | | | | | | | x | x | | TR |
| 20-Aug-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 24-Sep-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 26-Nov-12 | | | | | | | | | x | x | | TR |
| 16-April-13 | | | | | | | | | | | x | |
| 23-April-13 | | | | | | | | | | | x | |
| **Sproat Lake 2012** | | | | | | | | | | | | |
| 05-Jun-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 13-Jun-12 | | | | | | | | | x | x | | TR |
| 17-Jul-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 15-Aug-12 | | | | | | | | | x | x | | TR |
| 28-Aug-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 20-Sep-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 13-Nov-12 | | | | | | | | | x | x | | TR |
| 02-April-13 | | | | | | | | | | | x | |
| **Henderson Lake 2012** | | | | | | | | | | | | |
| 07-Jun-12 | x | x | x | x | x | x | | | | | | TR |
| 18-Jul-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 21-Aug-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 21-Aug-12 | | | | | | | | | x | x | | TR |
| 28-Sep-12 | x | x | x | x | x | x | D50 | x | | | | TR |
| 05-Dec-12 | | | | | | | | | x | x | | TR |
| 11-April-13 | | | | | | | | | | | x | |
| 01-May-13 | | | | | | | | | | | x | |

TEMPERATURES AND SECCHI DEPTHS in Great Central and Sproat lakes were similar (Table 34). Henderson Lake was slightly cooler in the spring but warmed in the summer; the thermocline was deeper in the summer-fall. As in past years, the Henderson Lake Secchi depths were slightly more shallow suggesting higher turbidity. This would be expected to reduce productive capacity for Henderson Lake juvenile sockeye salmon.

Table 34. Year 2012 water temperatures and Secchi depths.

**(a) Great Central Lake 2012**

| Depth (m) | 04-Jun-12 | 16-Jul-12 | 20-Aug-12 | 24-Sep-12 |
|---|---|---|---|---|
| 0 | 12.9 | 20.3 | 21.6 | 18.4 |
| 2 | 12.7 | 19.3 | 21.6 | 18.4 |
| 4 | 12.5 | 18.2 | 21.6 | 18.4 |
| 6 | 12.3 | 15.9 | 19.8 | 18.4 |
| 8 | 11.9 | 12.6 | 16.4 | 17.9 |
| 10 | 10.9 | 11.0 | 13.0 | 14.4 |
| 12 | 8.3 | 9.5 | 11.4 | 12.4 |
| 14 | 7.0 | 8.4 | 9.4 | 9.8 |
| 16 | 6.2 | 7.5 | 8.6 | 7.8 |
| 18 | 5.9 | 6.9 | 7.2 | 6.8 |
| 20 | 5.5 | 6.4 | 6.3 | 6.0 |
| 22 | 5.3 | 5.9 | 5.9 | 5.6 |
| **Secchi Depth (m)** | 9.5 | 7.9 | 10.4 | 13.6 |

**(b) Sproat Lake 2012**

| Depth (m) | 05-Jun-12 | 17-Jul-12 | 28-Aug-12 | 20-Sep-12 |
|---|---|---|---|---|
| 0 | 13.8 | 19.8 | 20.2 | 19.6 |
| 2 | 13.6 | 19.6 | 20.3 | 19.6 |
| 4 | 13.5 | 18.0 | 20.2 | 19.5 |
| 6 | 12.5 | 15.6 | 20.1 | 19.4 |
| 8 | 11.0 | 13.3 | 19.4 | 18.6 |
| 10 | 9.0 | 10.5 | 14.4 | 17.1 |
| 12 | 7.8 | 9.3 | 11.2 | 12.0 |
| 14 | 7.2 | 7.9 | 9.7 | 9.8 |
| 16 | 6.7 | 7.3 | 8.2 | 8.5 |
| 18 | 6.4 | 6.7 | 7.5 | 7.6 |
| 20 | 6.2 | 6.1 | 6.8 | 7.0 |
| 22 | 5.9 | 5.9 | 6.4 | 6.5 |
| **Secchi Depth (m)** | 10.6 | 15.9 | 15.9 | 15.9 |

(continued)

**(c) Henderson Lake 2012**

| Depth (m) | 07-Jun-12 | 18-Jul-12 | 21-Aug-12 | 28-Sep-12 |
|---|---|---|---|---|
| 0 | 10.1 | 19.8 | 20.7 | 18.3 |
| 2 | 7.6 | 19.7 | 20.7 | 18.3 |
| 4 | 8.5 | 19.3 | 20.7 | 18.3 |
| 6 | 8.7 | 18.4 | 20.7 | 18.2 |
| 8 | 9.3 | 17.4 | 20.5 | 18.2 |
| 10 | 9.9 | 15.3 | 20.4 | 18.1 |
| 12 | 10.3 | 11.6 | 18.5 | 17.6 |
| 14 | 10.8 | 9.7 | 17.2 | 15.5 |
| 16 | 11.3 | 7.7 | 13.5 | 11.2 |
| 18 | 11.7 | 6.7 | 11.7 | 8.8 |
| 20 | 11.8 | 6.1 | 8.6 | 7.2 |
| 22 | 11.8 | 5.7 | 7.0 | 6.4 |
| **Secchi Depth (m)** | 7.5 | 8.6 | 6.4 | 10.1 |

WATER CHEMISTRY: Results for TP were higher in Sproat Lake than they were for GCL and both were much higher than in Henderson Lake. The opposite was true for nitrogen and chlorophyll a, which were higher in Henderson Lake. Note also that nitrogen was high in the GCL hypolimnion, suggesting a nitrogen excess in the amount of fertilizer added later in the summer. Chlorophyll a was very low in Sproat Lake, and this combined with high TP concentrations, suggests heavy grazing by zooplankton. Chlorophyll a in Henderson Lake was high and this combined with very low TP concentrations suggests very low grazing pressure from zooplankton.

Table 35. Year 2012 water chemistry averaged over 2 stations in each lake.

| Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake 2012** | | | | | | | |
| 4-Jun-12 | 1, 3, 5 | 19.3 | 1.8 | 0.6 | 25 | 38.0 | 2.0 |
| 16-Jul-12 | 1, 3, 5 | 1.0 | 2.2 | 0.4 | 25 | 30.9 | 2.1 |
| 20-Aug-12 | 1, 3, 5 | 1.1 | 1.5 | 0.4 | 25 | 27.4 | 2.2 |
| 24-Sep-12 | 1, 3, 5 | 1.3 | 1.5 | 0.4 | 25 | 34.3 | 1.7 |
| **(b) Sproat Lake** | | | | | | | |
| 5-Jun-12 | 1, 3, 5 | 2.8 | 2.6 | 0.3 | 25 | 20.5 | 3.1 |
| 17-Jul-12 | 1, 3, 5 | 0.9 | 2.4 | 0.1 | 25 | 16.6 | 2.6 |
| 28-Aug-12 | 1, 3, 5 | 0.4 | 2.6 | 0.2 | 25 | 10.7 | 2.0 |
| 20-Sep-12 | 1, 3, 5 | 0.3 | 2.3 | 0.2 | 25 | 9.3 | 2.8 |
| **(c) Henderson Lake** | | | | | | | |
| 7-Jun-12 | 1, 3, 5 | 20.2 | <0.1 | 0.8 | 25 | 33.8 | <0.01 |
| 18-Jul-12 | 1, 3, 5 | 8.3 | <0.2 | 0.8 | 25 | 37.0 | <0.02 |
| 21-Aug-12 | 1, 3, 5 | 6.4 | <0.3 | 0.5 | 25 | 37.8 | <0.03 |
| 28-Sep-12 | 1, 3, 6 | 6.9 | <0.4 | 0.8 | 25 | 42.5 | <0.04 |

Water chemistry analyzed at Vancouver Island University showed that total alkalinity and calcium concentrations were highest in Sproat Lake, lower in GCL, and lowest in Henderson Lake. The low Ca concentrations observed in Henderson Lake may have negatively influenced chitin formation in *Daphnia*. Note the higher Na and Mg concentrations in Henderson Lake.

Table 36. Year 2012 summary of average, water chemistry data analyzed at Vancouver Island University.

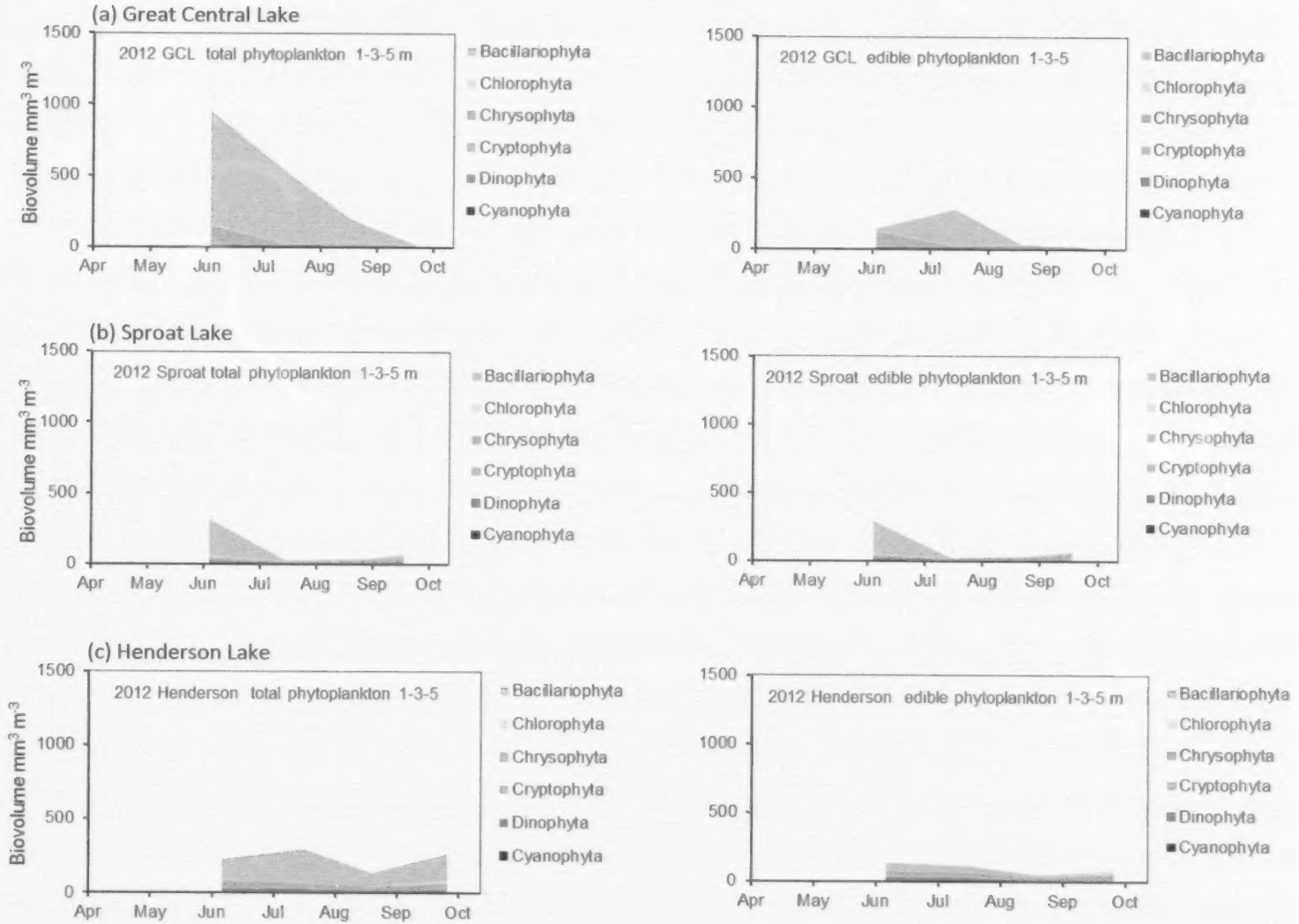
| Date | Total alkalinity ppm CaCO3 | Na ppm | Mg ppm | Ca ppm |
|---|---|---|---|---|
| **(a) Great Central Lake 2012** | | | | |
| 4-Jun-12 | 17.7 | 0.8 | 0.5 | 5.3 |
| 16-Jul-12 | 32.4 | 0.7 | 0.5 | 5.2 |
| 20-Aug-12 | 18.0 | 0.7 | 0.4 | 5.1 |
| 24-Sep-12 | 17.6 | 0.7 | 0.4 | 5.3 |
| **(b) Sproat Lake** | | | | |
| 5-Jun-12 | 31.7 | 1.0 | 0.7 | 9.5 |
| 17-Jul-12 | 19.1 | 0.9 | 0.7 | 9.3 |
| 28-Aug-12 | 31.5 | 1.0 | 0.7 | 9.1 |
| 20-Sep-12 | 31.1 | 1.1 | 0.7 | 9.6 |
| **(c) Henderson Lake** | | | | |
| 7-Jun-12 | 11.2 | 12.9 | 1.7 | 3.4 |
| 18-Jul-12 | 12.4 | 10.6 | 1.7 | 3.7 |
| 21-Aug-12 | 11.8 | 12.0 | 1.7 | 3.7 |
| 28-Sep-12 | 11.7 | 12.8 | 1.8 | 3.9 |

PHYTOPLANKTON BIOMASSES: Biomasses were recorded from samples taken at 1,3, and 5m (combined; Table 37, Figure 20 ). Densities, cell sizes, cell shapes, and biovolumes were recorded. Year 2012 GCL phytoplankton biomasses were similar to previous years. Bacillarophytes (diatoms) peaked early and edible algae biovolume was usually less than 200 $mm^3$ $m^{-3}$. Year 2012 Sproat Lake phytobiomass was lower than in GCL and Henderson lakes. This has also been the case in all previous years (2008-11). Low algal biovolumes combined with high zooplankton biomasses, suggests that grazing pressure in Sproat Lake was higher than it was in the other two lakes. Year 2012 Henderson Lake phytobiomass was lower than in 2010 and 2011 when diatoms bloomed in the midsummer, but was about equal to the biomasses seen in 2008 and 2009 when the diatom bloom was not observed. Henderson Lake edible biovolume was similar to 2008-2011 and was less than 200 $mm^3$ $m^{-3}$.

Table 37. Year 2012 total and edible phytoplankton biovolume. Values are expressed as $mm^3$ / $m^3$ .

| Sampling Date | Depth (m) | Cyanophyta | Dinophyta | Cryptophyta | Euglenophyta | Chrysophyta | Haptophyta | Tribophyta | Chlorophyta | Raphidophyta | Bacillariophyta | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | | | | | |
| Total Phytobiovolume | | | | | | | | | | | | |
| 04-Jun-12 | 1,3,5 | 0 | 13 | 10 | 0 | 126 | 1 | 2 | 5 | 0 | 797 | 954 |
| 16-Jul-12 | 1,3,5 | 0 | 15 | 0 | 0 | 5 | 0 | 1 | 3 | 0 | 496 | 521 |
| 20-Aug-12 | 1,3,5 | 0 | 7 | 0 | 0 | 25 | 0 | 12 | 5 | 0 | 154 | 203 |
| 24-Sep-12 | 1,3,5 | 0 | 2 | 1 | 0 | 9 | 0 | 6 | 5 | 0 | 4 | 27 |
| Edible Phytobiovolume | | | | | | | | | | | | |
| 04-Jun-12 | 1,3,5 | 0 | 13 | 10 | 0 | 103 | 1 | 2 | 3 | 0 | 14 | 146 |
| 16-Jul-12 | 1,3,5 | 0 | 15 | 0 | 0 | 5 | 0 | 1 | 3 | 0 | 257 | 281 |
| 20-Aug-12 | 1,3,5 | 0 | 7 | 0 | 0 | 24 | 0 | 12 | 5 | 0 | 0 | 48 |
| 24-Sep-12 | 1,3,5 | 0 | 2 | 1 | 0 | 9 | 0 | 6 | 3 | 0 | 0 | 22 |
| **(b) Sproat Lake** | | | | | | | | | | | | |
| Total Phytobiovolume | | | | | | | | | | | | |
| 05-Jun-12 | 1,3,5 | 0 | 47 | 12 | 0 | 56 | 2 | 0 | 38 | 0 | 1382 | 1537 |
| 17-Jul-12 | 1,3,5 | 1 | 15 | 0 | 0 | 14 | 0 | 2 | 8 | 0 | 78 | 118 |
| 28-Aug-12 | 1,3,5 | 0 | 16 | 1 | 0 | 16 | 0 | 6 | 12 | 0 | 13 | 64 |
| 20-Sep-12 | 1,3,5 | 0 | 51 | 7 | 0 | 29 | 0 | 8 | 4 | 0 | 10 | 109 |
| Edible Phytobiovolume | | | | | | | | | | | | |
| 05-Jun-12 | 1,3,5 | 0 | 29 | 2 | 0 | 20 | 0 | 1 | 8 | 0 | 235 | 295 |
| 17-Jul-12 | 1,3,5 | 0 | 9 | 2 | 0 | 9 | 0 | 0 | 1 | 0 | 7 | 27 |
| 28-Aug-12 | 1,3,5 | 0 | 3 | 1 | 0 | 27 | 0 | 2 | 0 | 0 | 8 | 42 |
| 20-Sep-12 | 1,3,5 | 0 | 2 | 4 | 0 | 47 | 1 | 2 | 1 | 0 | 17 | 74 |
| **(c) Henderson Lake** | | | | | | | | | | | | |
| Total Phytobiovolume | | | | | | | | | | | | |
| 07-Jun-12 | 1,3,5 | 0 | 33 | 2 | 0 | 52 | 2 | 2 | 3 | 0 | 140 | 234 |
| 18-Jul-12 | 1,3,5 | 0 | 31 | 6 | 0 | 36 | 4 | 11 | 1 | 0 | 222 | 311 |
| 21-Aug-12 | 1,3,5 | 0 | 19 | 2 | 0 | 25 | 1 | 4 | 2 | 0 | 91 | 144 |
| 28-Sep-12 | 1,3,5 | 0 | 25 | 2 | 0 | 46 | 2 | 13 | 12 | 0 | 180 | 280 |
| Edible Phytobiovolume | | | | | | | | | | | | |
| 07-Jun-12 | 1,3,5 | 0 | 33 | 2 | 0 | 50 | 2 | 2 | 3 | 0 | 53 | 145 |
| 18-Jul-12 | 1,3,5 | 0 | 31 | 6 | 0 | 36 | 4 | 11 | 1 | 0 | 44 | 132 |
| 21-Aug-12 | 1,3,5 | 0 | 10 | 2 | 0 | 25 | 1 | 4 | 2 | 0 | 14 | 58 |
| 28-Sep-12 | 1,3,5 | 0 | 12 | 2 | 0 | 46 | 2 | 13 | 11 | 0 | 7 | 93 |

Figure 20. Year 2012 total and edible phytoplankton biomass as $mm^3\ m^{-3}$, which approximates $\mu g\ L^{-1}$ wet weight.



ZOOPLANKTON BIOMASSES: Biomasses were highest in Sproat > GCL > Henderson Lake (Figure 21). Species diversity was about equal in all three lakes. Given that Henderson Lake edible phytoplankton biomasses were higher (Figure 20c) than they were in the other lakes (Figures 20 a and b), it seems likely that zooplankton were limited by factors other than simple food availability. Perhaps low temperatures and higher turbidity (Table 34) were implicated. Note that *Daphnia* were most common in Sproat Lake.

Table 38. Year 2012 total zooplankton density per L and biomass as µg/L dry weight.

**(a) Great Central Lake**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifers | *Leptodora* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 04-Jun-12 | 1.79 | 0.28 | 0.00 | 0.03 | 0.02 | 0.02 | 0.04 | 0.00 | 0.00 | 0.86 | 0.00 |
| 16-Jul-12 | 0.61 | 8.00 | 0.00 | 0.08 | 0.06 | 0.08 | 0.07 | 0.00 | 0.00 | 50.22 | 0.00 |
| 20-Aug-12 | 0.47 | 0.59 | 0.00 | 0.08 | 0.46 | 0.45 | 0.01 | 0.00 | 0.00 | 0.58 | 0.00 |
| 24-Sep-12 | 0.41 | 0.97 | 0.00 | 1.13 | 2.42 | 0.21 | 0.22 | 0.00 | 0.09 | 0.85 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 04-Jun-12 | 6.23 | 0.06 | 0.05 | 0.23 | 0.06 | 0.07 | 0.04 | 0.00 | 0.00 | 0.28 | 0.00 |
| 16-Jul-12 | 1.84 | 1.24 | 0.07 | 0.35 | 0.13 | 0.22 | 0.07 | 0.00 | 0.00 | 6.66 | 0.00 |
| 20-Aug-12 | 2.11 | 0.11 | 0.00 | 0.50 | 1.18 | 2.72 | 0.01 | 0.00 | 0.00 | 0.05 | 0.00 |
| 24-Sep-12 | 1.63 | 0.18 | 0.10 | 6.00 | 6.29 | 1.82 | 0.22 | 0.00 | 0.32 | 0.07 | 0.00 |

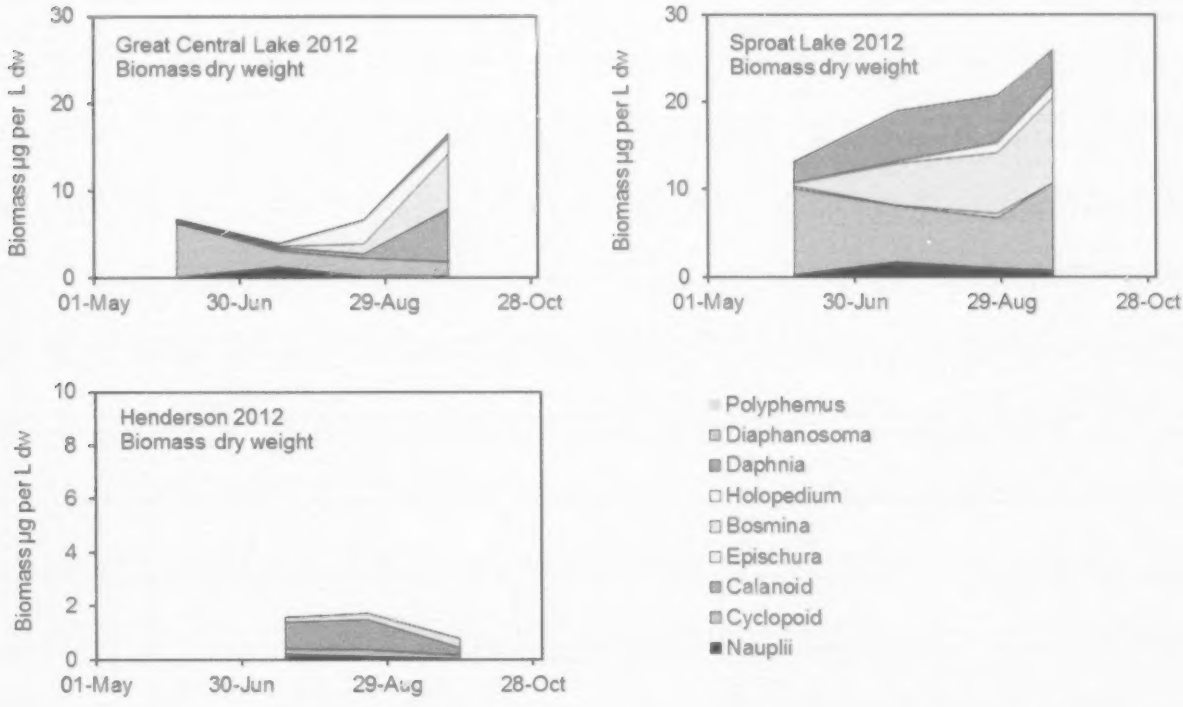
**(b) Sproat Lake**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifers | *Leptodora* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 05-Jun-12 | 2.59 | 1.38 | 0.01 | 0.00 | 0.11 | 0.00 | 0.76 | 0.00 | 0.00 | 0.66 | 0.00 |
| 17-Jul-12 | 2.42 | 8.67 | 0.01 | 0.00 | 2.20 | 0.08 | 2.14 | 0.00 | 0.00 | 2.67 | 0.00 |
| 27-Aug-12 | 1.50 | 5.00 | 0.03 | 0.00 | 2.17 | 0.24 | 2.40 | 0.00 | 0.00 | 2.26 | 0.00 |
| 19-Sep-12 | 3.66 | 3.67 | 0.00 | 0.00 | 2.89 | 0.41 | 1.67 | 0.13 | 0.00 | 4.47 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 05-Jun-12 | 9.85 | 0.24 | 0.28 | 0.00 | 0.37 | 0.00 | 2.44 | 0.00 | 0.00 | 0.20 | 0.00 |
| 17-Jul-12 | 6.43 | 1.68 | 0.05 | 0.00 | 4.82 | 0.22 | 5.75 | 0.02 | 0.00 | 0.24 | 0.00 |
| 27-Aug-12 | 5.81 | 0.96 | 0.49 | 0.00 | 6.93 | 1.14 | 5.39 | 0.00 | 0.00 | 0.22 | 0.00 |
| 19-Sep-12 | 10.01 | 0.69 | 0.00 | 0.00 | 9.82 | 1.43 | 4.01 | 0.35 | 0.00 | 0.37 | 0.00 |

**(b) Henderson Lake**

| Sampling Date | Cyclopoid adult & copepodids | Nauplii | *Epischura* adult & copepodids | Calanoid adult & copepodids | *Bosmina* | *Holopedium* | *Daphnia* | *Polyphemus* | *Diaphanosoma* | Rotifers | *Leptodora* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density per L** | | | | | | | | | | | |
| 18-Jul-12 | 0.66 | 0.00 | 0.45 | 0.12 | 0.00 | 0.01 | 0.00 | 0.00 | 0.15 | 0.00 | |
| 21-Aug-12 | 0.32 | 0.00 | 0.51 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 28-Sep-12 | 0.08 | 0.00 | 0.09 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | |
| **Biomass per L** | | | | | | | | | | | |
| 18-Jul-12 | 0.19 | 0.00 | 1.00 | 0.17 | 0.00 | 0.01 | 0.00 | 0.00 | 0.09 | 0.00 | |
| 21-Aug-12 | 0.11 | 0.00 | 1.12 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 28-Sep-12 | 0.03 | 0.00 | 0.30 | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |

Figure 21. Year 2012 zooplankton biomasses as µg $L^{-1}$ dry weight. Note the y-axis used for the Henderson plot.



FISH DENSITIES, LENGTHS, AND WEIGHTS: Results are summarized in Table 39. Weights have been corrected for shrinkage due to the ethanol used as a preservative. 95 % confidence intervals around the means of fish abundance are also provided. The mean of one or more winter survey values (Nov-Feb) is considered to be useable as a spring smolt production estimate when 95% confidence intervals suggest multiple estimates be treated as replicates. If winter survey values differ significantly, then the latest survey value is considered to represent the best annual estimate of smolt production.

Table 39. Year 2012 fish densities, lengths, and weights for Great Central, Sproat, and Henderson Lakes. SB = stickleback.

| Sampling Date | Total Limnetic Fish Density | Limnetic Fish Density per ha | Conf. Interval (%) | Sockeye Density per ha | SB Density per ha | Sockeye Mean Length (mm) | Sockeye Mean Weight (g) | Sockeye Sample Size (n) |
|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | |
| 11-Jun-12 | 9,890,539 | 1,954 | 53 | 1,954 | 0 | 37 | 0.5 | 106 |
| 13-Aug-12 | 26,914,304 | 5,291 | 39 | 5,291 | 0 | 37 | 0.4 | 203 |
| 26-Nov-12 | 15,175,000 | 2,984 | 19 | 2,984 | 0 | 46 | 1.2 | 102 |
| 12-Feb-13 | trawl only | | | | | 51 | 1.5 | 102 |
| 16-Apr-13 | Smolts | | | | | 67 | 2.8 | 77 |
| 23-Apr-13 | Smolts | | | | | 77 | | 38 |
| **(b) Sproat Lake** | | | | | | | | |
| 13-Jun-12 | 15,262,441 | 4,043 | 37 | 4,043 | 0 | 31 | 0.3 | 102 |
| 15-Aug-12 | 21,862,120 | 5,791 | 35 | 5,791 | 0 | 44 | 0.9 | 102 |
| 13-Nov-12 | 14,526,189 | 3,848 | 14 | 3,848 | 0 | 58 | 2.0 | 153 |
| 26-Feb-13 | trawl only | | | | | 60 | 2.4 | 15 |
| 02-Apr-13 | Smolts | | | | | 92 | | 17 |
| **(c) Henderson Lake** | | | | | | | | |
| 19-Jun-12 | trawl only | | | | 0 | 25 | 0.3 | 12 |
| 21-Aug-12 | 4,155,368 | 2,690 | 22 | 2,690 | 0 | 41 | 0.6 | 38 |
| 05-Dec-12 | 3,142,454 | 2,034 | 21 | 2,034 | 0 | 46 | 1.0 | 102 |
| 11-Apr-13 | Smolts | | | | | 48 | 1.1 | 47 |
| 01-May-13 | Smolts | | | | | 46 | 0.9 | 220 |

FISH DIETS

Table 40. Year 2012 average number of prey per fish stomach.

| Sampling Date | Number stomachs processed | *Bosmina* | Cyclops | *Daphnia* | *Diaphanosoma* | Calanoid | Epischura | Holopedium | Leptodora | Polyphemus | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2012** | | | | | | | | | | | |
| 11-Jun-12 | 30 | 9.7 | 35.6 | 0.0 | | 0.0 | 2.6 | 0.4 | 0.0 | | **48** |
| 13-Aug-12 | 30 | 24.4 | 4.3 | 0.0 | | 0.0 | 2.5 | 49.6 | 0.0 | | **81** |
| 26-Nov-12 | 30 | 174.4 | 28.8 | 4.3 | | 0.0 | 42.1 | 2.7 | 0.0 | | **252** |
| **Sproat Lake 2012** | | | | | | | | | | | |
| 13-Jun-12 | 30 | 29.5 | 55.1 | 14.0 | 1.6 | | 0.4 | 0.4 | | 0.2 | **101** |
| 15-Aug-12 | 30 | 204.3 | 60.1 | 1.1 | 0.0 | | 0.7 | 10.3 | | 0.7 | **277** |
| 13-Nov-12 | 30 | 104.1 | 163.8 | 0.0 | 0.0 | | 3.6 | 0.7 | | 0.0 | **272** |
| **Henderson Lake 2012** | | | | | | | | | | | |
| 19-Jun-12 | 8 | 2.4 | 0.0 | 0.0 | | 30.9 | 0.3 | | | | **34** |
| 21-Aug-12 | 30 | 6.6 | 2.9 | 0.0 | | 22.6 | 0.0 | | | | **32** |
| 12-Dec-12 | 30 | 0.1 | 0.1 | 0.1 | | 0.0 | 0.0 | | | | **0** |

# YEAR 2013: GREAT CENTRAL, SPROAT, AND HENDERSON LAKES DATA SUMMARY

## SAMPLING SCHEDULE FOR 2013

Table 41. Samples collected during 2013. x = sample collected. D-50 = zooplankton sampled in the day at 0-50 m. 0 = data not collected. TR = trip report available.

| Survey Date | DFO chemistry | VIU chemistry | Temperature | Oxygen | Secchi | Phytoplankton 1,3,5 | Zooplankton | Rigosha | Acoustic Records | Biosampling fish | Fish stomachs | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2013** | | | | | | | | | | | | |
| 16-May-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 17-Jun-13 | x | x | x | x | x | nd | D50 | x | | x | x | TR |
| 21-Jul-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 12-Aug-13 | x | x | x | x | x | nd | D50 | x | x | | | TR |
| 16-Sep-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 16-Oct-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 5-Nov-13 | | | | | | | D50 | x | | | | TR |
| 20-Nov-13 | | | | | | | | | x | x | x | TR |
| 11-Feb-14 | | | | | | | | | x | x | | TR |
| **Sproat Lake 2013** | | | | | | | | | | | | |
| 15-May-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 12-Jun-13 | x | x | x | x | x | nd | D50 | x | x | x | x | TR |
| 12-Jul-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 26-Aug-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 27-Aug-13 | | | | | | | | | x | x | x | TR |
| 17-Sep-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 15-Oct-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 05-Nov-13 | | | | | | nd | D50 | | | | | TR |
| 19-Nov-13 | | | | | | | | | x | x | x | TR |
| **Henderson Lake 2013** | | | | | | | | | | | | |
| 17-May-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 19-Jun-13 | x | x | x | x | x | nd | D50 | x | | x | x | TR |
| 09-Jul-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 07-Aug-13 | x | x | x | x | x | nd | D50 | x | x | | | TR |
| 18-Sep-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 21-Oct-13 | x | x | x | x | x | nd | D50 | x | | | | TR |
| 04-Mar-14 | | | | | | | | | x | x | x | TR |

TEMPERATURES AND SECCHI DEPTHS. Sproat had higher Secchi depths than GCL but the temperatures in the two lakes were similar. Henderson Lake was slightly cooler in the spring but warmed through the summer and had a deeper thermocline and deeper epilimnion in the summer-fall. As in past years, the Henderson Lake Secchi depths were shallower, suggesting higher turbidity.

Table 42. Year 2013 water temperatures and Secchi depths.

**Great Central Lake 2013**

| Depth (m) | 16-May-13 | 17-Jun-13 | 21-Jul-13 | 12-Aug-13 | 16-Sep-13 | 16-Oct-13 |
|---|---|---|---|---|---|---|
| 0 | 14.1 | 18.7 | 21.4 | 22.3 | 20.9 | 14.3 |
| 2 | 13.9 | 18.1 | 21.2 | 22.2 | 21.0 | 14.4 |
| 4 | 13.9 | 17.7 | 20.8 | 22.1 | 20.9 | 14.4 |
| 6 | 12.8 | 16.3 | 20.5 | 21.8 | 20.4 | 14.4 |
| 8 | 11.1 | 12.9 | 15.3 | 18.5 | 17.9 | 14.4 |
| 10 | 8.9 | 10.0 | 12.4 | 13.7 | 15.9 | 13.5 |
| 12 | 7.7 | 8.8 | 10.6 | 11.9 | 12.2 | 12.2 |
| 14 | 7.0 | 7.9 | 8.8 | 10.2 | 10.1 | 10.5 |
| 16 | 6.4 | 7.3 | 7.5 | 9.3 | 8.4 | 9.1 |
| 18 | 5.9 | 6.7 | 6.9 | 8.1 | 7.4 | 7.8 |
| 20 | 5.6 | 6.0 | 6.0 | 7.0 | 6.6 | 7.0 |
| 22 | 5.4 | 5.6 | 5.7 | 6.4 | 5.9 | 6.2 |
| Secchi Depth (m) | 9.2 | 9.2 | 13.1 | 10.2 | 12.4 | 11.3 |

**Sproat Lake 2013**

| Depth (m) | 15-May-13 | 12-Jul-13 | 26-Aug-13 | 17-Sep-13 | 15-Oct-13 |
|---|---|---|---|---|---|
| 0 | 14.8 | 16.8 | 21.3 | 21.0 | 14.7 |
| 2 | 14.7 | 16.5 | 21.3 | 21.0 | 14.7 |
| 4 | 14.5 | 16.3 | 21.3 | 20.9 | 14.7 |
| 6 | 11.1 | 16.1 | 21.2 | 20.9 | 14.7 |
| 8 | 9.8 | 12.2 | 21.2 | 20.5 | 14.7 |
| 10 | 9.1 | 10.7 | 16.5 | 17.0 | 14.2 |
| 12 | 8.4 | 9.1 | 12.9 | 13.2 | 13.2 |
| 14 | 7.8 | 8.2 | 10.1 | 10.9 | 11.6 |
| 16 | 7.2 | 7.3 | 8.5 | 9.0 | 9.9 |
| 18 | 6.7 | 6.7 | 7.8 | 8.0 | 8.8 |
| 20 | 6.3 | 6.3 | 7.4 | 7.5 | 7.9 |
| 22 | 5.9 | 6.0 | 6.8 | 6.9 | 7.2 |
| Secchi Depth (m) | 12.5 | 12.6 | 15.6 | 15.6 | 11.85 |

**Henderson Lake 2013**

| Depth (m) | 17-May-13 | 19-Jun-13 | 09-Jul-13 | 07-Aug-13 | 18-Sep-13 | 21-Oct-13 |
|---|---|---|---|---|---|---|
| 0 | 13.2 | 16.5 | 20.1 | 21.1 | 19.8 | 14.1 |
| 2 | 13.1 | 16.5 | 20.0 | 21.1 | 19.8 | 14.1 |
| 4 | 12.5 | 16.5 | 19.3 | 20.6 | 19.7 | 14.0 |
| 6 | 11.8 | 16.5 | 18.9 | 20.5 | 19.6 | 14.0 |
| 8 | 11.6 | 16.2 | 17.3 | 20.4 | 19.5 | 14.0 |
| 10 | 11.1 | 15.8 | 15.9 | 20.3 | 19.1 | 13.9 |
| 12 | 10.6 | 15.3 | 13.3 | 19.9 | 17.3 | 13.9 |
| 14 | 10.3 | 13.8 | 10.5 | 19.3 | 15.4 | 13.7 |
| 16 | 9.9 | 11.7 | 8.8 | 16.4 | 12.9 | 13.3 |
| 18 | 9.3 | 9.8 | 8.0 | 12.9 | 10.8 | 12.2 |
| 20 | 8.6 | 8.6 | 7.3 | 10.1 | 8.3 | 9.3 |
| 22 | 7.7 | 7.8 | 6.6 | 8.1 | 7.2 | 7.6 |
| Secchi Depth (m) | 7.1 | 6.8 | 8.4 | 8.0 | 8.7 | 8.4 |

WATER CHEMISTRY: Summary estimates for TP were similar in Sproat Lake and GCL. Both lakes had much higher values than in Henderson Lake. The opposite was true for nitrate and chlorophyll a, which were higher in Henderson Lake. During the late summer, hypolimnetic nitrogen was high in GCL but much lower in Sproat Lake. This suggests that there may have been excess nitrogen added to GCL. It may also suggest that there was a hypolimnetic algal bloom in Sproat Lake resulting in high rates of nitrogen consumption and subsequent loss from the system. Chlorophyll a was very low in Sproat Lake, and this combined with high TP concentrations, suggests heavy grazing by zooplankton. Chlorophyll a in Henderson Lake was high and this combined with low TP concentrations suggests very low grazing pressure from zooplankton.

Table 43. Year 2013 water chemistry averaged over 2 stations in each lake.

**(a) Great Central Lake 2013**

| Sampling Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| 16-May-13 | 1, 3, 5 | 14.0 | nd | 0.8 | 25 | 27.7 | nd |
| 17-Jun-13 | 1, 3, 5 | 0.4 | nd | 0.5 | 25 | 29.7 | nd |
| 21-Jul-13 | 1, 3, 5 | 0.4 | nd | 0.3 | 25 | 30.6 | nd |
| 12-Aug-13 | 1, 3, 5 | 0.5 | 2.2 | 0.3 | 25 | 28.3 | 2.4 |
| 16-Sep-13 | 1, 3, 5 | 0.5 | nd | 0.5 | 25 | 31.7 | 2.2 |
| 15-Oct-13 | 1, 3, 5 | 0.7 | 5.5 | 0.8 | 25 | 29.9 | 2.0 |

**(b) Sproat Lake 2013**

| Sampling Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| 18-May-13 | 1, 3, 5 | 0.4 | 2.8 | 0.4 | 25 | 16.9 | 2.9 |
| 12-Jun-13 | 1, 3, 5 | 0.2 | 2.8 | 0.2 | 25 | 20.4 | 3.3 |
| 12-Jul-13 | 1, 3, 5 | 0.3 | 2.2 | 0.2 | 25 | 15.8 | 2.3 |
| 26-Aug-13 | 1, 3, 5 | 0.4 | nd | 0.2 | 25 | 0.4 | 2.6 |
| 17-Sep-13 | 1, 3, 5 | 0.6 | nd | 0.3 | 25 | 0.6 | nd |
| 16-Oct-13 | 1, 3, 5 | 0.4 | 2.3 | 0.7 | 25 | 4.5 | 2.0 |

**(c) Henderson Lake 2013**

| Sampling Date | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ | Chlorophyll µg $L^{-1}$ | Depth (m) | Nitrate µg $L^{-1}$ | TP µg $L^{-1}$ |
|---|---|---|---|---|---|---|---|
| 17-May-13 | 1, 3, 5 | 19.8 | nd | 0.8 | 25 | 29.9 | nd |
| 19-Jun-13 | 1, 3, 5 | 13.7 | 1.7 | 0.8 | 25 | 31.3 | nd |
| 9-Jul-13 | 1, 3, 5 | 11.5 | nd | 0.7 | 25 | 36.1 | nd |
| 7-Aug-13 | 1, 3, 5 | 7.4 | nd | 0.8 | 25 | 30.2 | nd |
| 18-Sep-13 | 1, 3, 5 | 10.2 | nd | 1.0 | 25 | 34.0 | nd |
| 21-Oct-13 | 1, 3, 5 | 18.3 | 1.5 | 1.2 | 25 | 40.3 | 2.1 |

Water chemistry analyzed at Vancouver Island University showed that total alkalinity and calcium concentrations were highest in Sproat Lake, lower in GCL and lowest in Henderson Lake. Our previous concern was that low Ca concentrations observed in Henderson Lake may have negatively influenced chitin formation in *Daphnia*. During 2013, this was not an issue.

Table 44. Year 2013 summary of average water chemistry data analyzed at Vancouver Island University.

**(a) Great Central Lake**

| Sampling Date | Total alkalinity ppm CaCO3 | Na ppm | Mg ppm | Ca ppm |
|---|---|---|---|---|
| 16-May-13 | 16.1 | 0.6 | 0.4 | 5.3 |
| 17-Jun-13 | 16.2 | 0.7 | 0.4 | 5.2 |
| 21-Jul-13 | 15.1 | 0.7 | 0.4 | 4.9 |
| 12-Aug-13 | 14.9 | 0.8 | 0.4 | 5.4 |
| 16-Sep-13 | 14.8 | 0.5 | 2.0 | 4.4 |
| 15-Oct-13 | 14.5 | 0.6 | 0.4 | 4.5 |

**(b) Sproat Lake**

| Sampling Date | Total alkalinity ppm CaCO3 | Na ppm | Mg ppm | Ca ppm |
|---|---|---|---|---|
| 15-May-13 | 27.2 | 1.2 | 0.7 | 9.5 |
| 12-Jun-13 | 27.1 | 1.0 | 0.7 | 9.2 |
| 12-Jul-13 | 26.3 | 1.0 | 0.6 | 8.9 |
| 26-Aug-13 | 27.9 | 1.0 | 0.7 | 9.6 |
| 17-Sep-13 | 26.1 | 0.9 | 0.6 | 8.6 |
| 16-Oct-13 | 25.3 | 0.8 | 0.5 | 6.5 |

**(c) Henderson Lake**

| Sampling Date | Total alkalinity ppm CaCO3 | Na ppm | Mg ppm | Ca ppm |
|---|---|---|---|---|
| 17-May-13 | 10.0 | 10.2 | 1.4 | 3.3 |
| 19-Jun-13 | 10.2 | 9.0 | 1.3 | 3.4 |
| 9-Jul-13 | 9.6 | 8.9 | 1.2 | 3.8 |
| 28-Aug-13 | 17.6 | 0.6 | 0.8 | 5.3 |
| 19-Sep-13 | 17.5 | 0.6 | 0.8 | 4.8 |
| 21-Oct-13 | 8.8 | 8.2 | 1.2 | 3.8 |

PHYTOPLANKTON BIOMASSES: Phytoplankton samples were damaged prior to reaching the lab for analysis and thus, most of the resulting counts were much lower than in previous years. The data have been discarded.

ZOOPLANKTON BIOMASSES: Biomasses were highest in Sproat > GCL >> Henderson Lake (Figure 22). Species diversity was about equal in Sproat and GCL and was lower in Henderson Lake. Given that Henderson Lake phytoplankton biomasses are typically in the same range as they are in GCL, it is not clear why Henderson Lake zooplankton biomasses are so low. Note that *Daphnia* were abundant in Sproat Lake. Henderson Lake *Skistodiaptomus* (calanoid copepod) significantly increased in the fall.

Table 45. Year 2013 zooplankton density per L and biomass as µ/L dry weight

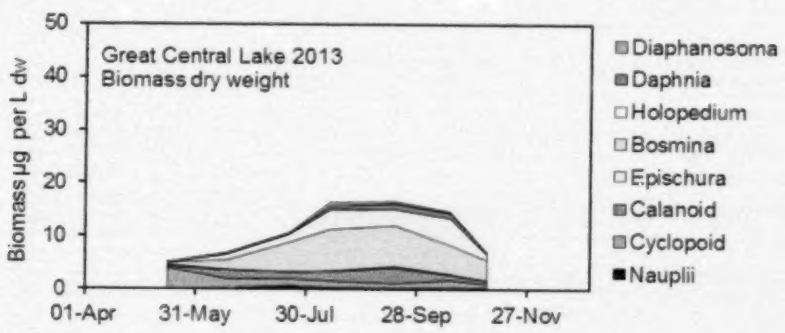
| Sampling Date | Rotifers | Nauplii | Cyclopoid adult & copepodids | Calanoid adult & copepodids | *Epischura* adult & copepodids | *Bosmina* | *Daphnia* | *Diaphanosoma* | *Polyphemous* | *Holopedium* |
|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake 2013** | | | | | | | | | | |
| **Density per L** | | | | | | | | | | |
| 16-May-13 | 0.00 | 0.00 | 1.48 | 0.03 | 0.00 | 0.25 | 0.01 | 0.00 | 0.00 | 0.01 |
| 17-Jun-13 | 0.00 | 0.00 | 0.83 | 0.26 | 0.00 | 0.89 | 0.14 | 0.00 | 0.00 | 0.55 |
| 21-Jul-13 | 0.00 | 0.00 | 0.67 | 0.59 | 0.00 | 2.33 | 0.13 | 0.00 | 0.01 | 0.69 |
| 12-Aug-13 | 0.00 | 0.00 | 0.56 | 0.53 | 0.00 | 3.25 | 0.49 | 0.00 | 0.24 | 0.75 |
| 16-Sep-13 | 0.00 | 0.00 | 0.33 | 0.82 | 0.00 | 2.53 | 0.58 | 0.00 | 0.13 | 0.43 |
| 16-Oct-13 | 0.00 | 0.00 | 0.59 | 0.16 | 0.00 | 1.86 | 0.43 | 0.00 | 0.09 | 1.10 |
| 05-Nov-13 | 0.00 | 0.00 | 0.29 | 0.12 | 0.00 | 1.49 | 0.19 | 0.00 | 0.02 | 0.34 |
| **Biomass per L** | | | | | | | | | | |
| 16-May-13 | 0.09 | 0.11 | 3.82 | 0.34 | 0.28 | 0.42 | 0.02 | 0.00 | 0.00 | 0.02 |
| 17-Jun-13 | 0.16 | 0.21 | 1.76 | 1.59 | 0.11 | 1.76 | 0.25 | 0.00 | 0.00 | 1.12 |
| 21-Jul-13 | 0.14 | 0.70 | 1.24 | 1.33 | 0.02 | 5.53 | 0.22 | 0.03 | 0.03 | 1.57 |
| 12-Aug-13 | 0.02 | 0.34 | 1.26 | 1.79 | 0.09 | 7.81 | 0.69 | 0.70 | 0.00 | 3.69 |
| 16-Sep-13 | 0.06 | 0.26 | 0.91 | 2.90 | 0.30 | 7.67 | 1.08 | 0.41 | 0.00 | 3.03 |
| 16-Oct-13 | 0.10 | 0.38 | 1.42 | 0.98 | 0.12 | 5.47 | 0.96 | 0.25 | 0.00 | 5.06 |
| 05-Nov-13 | 0.14 | 0.33 | 0.66 | 0.64 | 0.06 | 3.84 | 0.30 | 0.07 | 0.00 | 1.12 |

(continued)

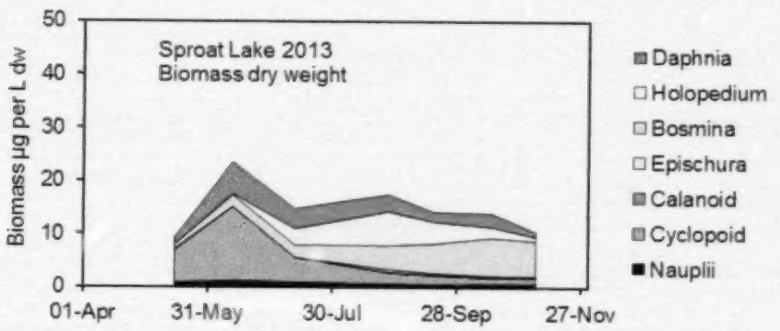
| Sampling Date | Rotifers | Nauplii | Cyclopoid adult & copepodids | Calanoid adult & copepodids | *Epischura* adult & copepodids | *Bosmina* | *Daphnia* | *Diaphanosoma* | *Holopedium* | *Polyphemus* | *Leptodora* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **(b) Sproat Lake 2013** | | | | | | | | | | | |
| **Density per L** | | | | | | | | | | | |
| 15-May-13 | 5.11 | 4.22 | 2.51 | 0.01 | 0.01 | 0.42 | 0.71 | 0.00 | 0.01 | 0.00 | 0.00 |
| 12-Jun-13 | 4.45 | 7.09 | 6.40 | 0.00 | 0.02 | 0.97 | 2.73 | 0.00 | 0.08 | 0.00 | 0.00 |
| 12-Jul-13 | 3.83 | 6.67 | 1.76 | 0.00 | 0.00 | 0.93 | 2.00 | 0.00 | 1.15 | 0.02 | 0.00 |
| 26-Aug-13 | 3.67 | 4.22 | 0.77 | 0.04 | 0.04 | 1.44 | 1.25 | 0.00 | 1.72 | 0.00 | 0.00 |
| 17-Sep-13 | 6.00 | 4.19 | 0.61 | 0.05 | 0.03 | 1.92 | 0.80 | 0.00 | 1.33 | 0.00 | 0.00 |
| 15-Oct-13 | 1.60 | 4.62 | 0.40 | 0.06 | 0.00 | 2.50 | 1.03 | 0.00 | 0.70 | 0.00 | 0.00 |
| 05-Nov-13 | 0.52 | 4.56 | 0.66 | 0.03 | 0.01 | 2.58 | 0.53 | 0.02 | 0.30 | 0.01 | 0.00 |
| **Biomass per L** | | | | | | | | | | | |
| 15-May-13 | 0.71 | 0.88 | 6.07 | 0.03 | 0.13 | 0.83 | 1.25 | 0.00 | 0.04 | 0.00 | 0.02 |
| 12-Jun-13 | 0.42 | 1.24 | 13.78 | 0.00 | 0.10 | 2.18 | 5.90 | 0.00 | 0.23 | 0.00 | 0.24 |
| 12-Jul-13 | 0.32 | 0.98 | 4.61 | 0.01 | 0.00 | 2.31 | 3.74 | 0.00 | 3.09 | 0.09 | 0.08 |
| 26-Aug-13 | 0.31 | 0.71 | 2.06 | 0.14 | 0.48 | 4.40 | 3.19 | 0.00 | 6.45 | 0.00 | 0.15 |
| 17-Sep-13 | 0.16 | 0.62 | 1.67 | 0.12 | 0.26 | 5.54 | 1.82 | 0.00 | 4.14 | 0.00 | 0.00 |
| 15-Oct-13 | 0.14 | 0.72 | 1.11 | 0.34 | 0.01 | 7.13 | 2.53 | 0.00 | 2.04 | 0.00 | 0.00 |
| 05-Nov-13 | 0.04 | 0.73 | 1.18 | 0.17 | 0.04 | 6.58 | 0.88 | 0.06 | 0.85 | 0.03 | 0.00 |
| **(c) Henderson Lake** | | | | | | | | | | | |
| **Density per L** | | | | | | | | | | | |
| 17-May-13 | 0.02 | 1.18 | 0.07 | 0.21 | 0.00 | 0.14 | 0.00 | 0.00 | | | |
| 19-Jun-13 | 0.82 | 2.11 | 0.09 | 0.50 | 0.00 | 1.19 | 0.00 | 0.01 | | | |
| 09-Jul-13 | 1.45 | 0.40 | 0.05 | 0.58 | 0.00 | 1.83 | 0.00 | 0.00 | | | |
| 07-Aug-13 | 0.82 | 0.15 | 0.07 | 0.51 | 0.00 | 0.32 | 0.01 | 0.01 | | | |
| 18-Sep-13 | 5.44 | 0.43 | 0.05 | 0.19 | 0.00 | 0.39 | 0.00 | 0.01 | | | |
| 21-Oct-13 | 3.17 | 10.08 | 1.56 | 4.64 | 0.00 | 1.92 | 0.05 | 0.04 | | | |
| **Biomass per L** | | | | | | | | | | | |
| 17-May-13 | 0.00 | 0.23 | 0.21 | 0.68 | 0.00 | 0.34 | 0.00 | 0.00 | | | |
| 19-Jun-13 | 0.07 | 0.37 | 0.32 | 1.59 | 0.00 | 1.08 | 0.00 | 0.02 | | | |
| 09-Jul-13 | 0.13 | 0.11 | 0.12 | 0.87 | 0.00 | 1.54 | 0.00 | 0.00 | | | |
| 07-Aug-13 | 0.08 | 0.03 | 0.14 | 1.40 | 0.00 | 0.58 | 0.00 | 0.01 | | | |
| 18-Sep-13 | 1.19 | 0.11 | 0.08 | 0.52 | 0.00 | 0.43 | 0.00 | 0.02 | | | |
| 21-Oct-13 | 0.26 | 2.25 | 4.56 | 18.12 | 0.00 | 3.43 | 0.07 | 0.09 | | | |

Figure 22. Year 2013 zooplankton biomasses as µg $L^{-1}$ dry weight.

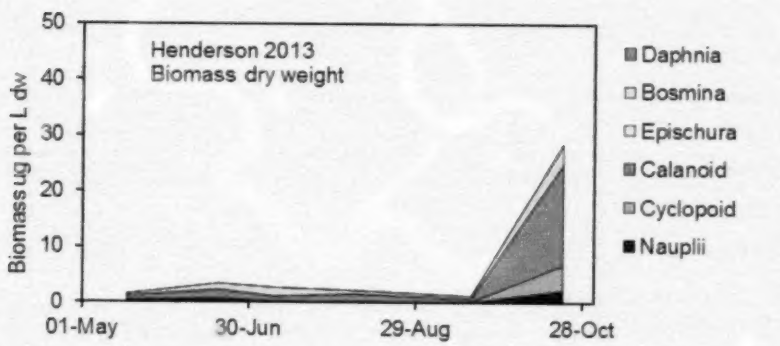
(a)




(b)




(c)



FISH DENSITIES, LENGTHS, AND WEIGHTS are summarized in Table 46. Weights have been corrected for shrinkage due to the ethanol used as a preservative. As was the case in previous years, Sproat Lake fry were the largest (both length and weight), followed by GCL fry; Henderson fry were the smallest. 95 % confidence intervals around the means of fish abundance are also provided. The mean of one or more winter survey values (Nov-Feb) is considered to be useable as a spring smolt production estimate when 95% confidence intervals suggest multiple estimates be treated as replicates. If winter survey values differ significantly, then the latest survey value is considered to represent the best annual estimate of smolt production.

Table 46. Year 2013 mean fish densities, lengths, and weights. Weights have been corrected for shrinking due to the ethanol used as a preservative.

| Sampling Date | Total Limnetic Fish Density | Limnetic Fish Density per ha | Conf. Intervals (%) | Sockeye Density per ha | SB Density per ha | Sockeye Mean Length (mm) | Sockeye Mean Weight (g) | Sockeye Sample Size (n) |
|---|---|---|---|---|---|---|---|---|
| **(a) Great Central Lake** | | | | | | | | |
| 17-Jun-13 | trawl only | | | | | 34 | 0.4 | 102 |
| 12-Aug-13 | 19,156,000 | 3,800 | 43 | 3,800 | 0 | 42 | nd | 51 |
| 20-Nov-13 | 7,927,000 | 1,600 | 35 | 1,600 | 0 | 53 | 1.6 | 102 |
| 11-Feb-14 | 10,002,000 | 2,000 | 17 | 2,000 | | nd | nd | * |
| **(b) Sproat Lake** | | | | | | | | |
| 12-Jun-13 | trawl only | | | | | 30 | 0.3 | 81 |
| 27-Aug-13 | 11,210,000 | 3,000 | 20 | 3,000 | 0 | 49 | 1.5 | 67 |
| 19-Nov-13 | 3,687,000 | 1,000 | 31 | 1,000 | 0 | 70 | 3.3 | 37 |
| **(c) Henderson Lake** | | | | | | | | |
| 19-Jun-13 | trawl only | | | | | 33 | 0.4 | 50 |
| 07-Aug-13 | 3,926,000 | 2,500 | 21 | 1,200 | 1,300 | nd | nd | |
| 04-Mar-14 | 1,811,000 | 1,200 | 20 | 800 | 400 | 46 | 0.4 | 37 |
| 25-Apr-14 | smolt | | | | | 49 | 0.84 | 61 |
| 07-May-14 | smolt | | | | | 51 | 0.93 | 31 |

* Acoustics survey only

FISH DIETS

Table 47. Year 2013 average number of prey per fish stomach.

| Sampling Date | Number stomachs processed | Cyclops | Calanoid | *Epischura* | *Daphnia* | *Bosmina* | *Diaphanosoma* | *Holopedium* | Chironomid larvae | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Great Central Lake 2013** | | | | | | | | | | |
| 17-Jun-13 | 32 | 224.5 | 3.9 | 1.0 | 4.9 | 4.9 | 0.0 | 1.0 | 0.0 | **240** |
| 20-Nov-13 | 30 | 86.3 | 116.8 | 0.0 | 182.9 | 1021.0 | 5.1 | 15.2 | 0.0 | **1427** |
| **Sproat Lake 2013** | | | | | | | | | | |
| 12-Jun-13 | 30 | 17.8 | 0.0 | 0.0 | 7.5 | 13.1 | 0.0 | 7.3 | 1.4 | **47** |
| 27-Aug-13 | 30 | 80.5 | 0.0 | 1.0 | 21.3 | 69.8 | 0.0 | 33.0 | 0.0 | **206** |
| 19-Nov-13 | 30 | 71.1 | 0.0 | 0.0 | 12.8 | 214.8 | 1.4 | 25.6 | 0.0 | **326** |
| **Henderson Lake 2013** | | | | | | | | | | |
| 17-Jun-13 | 30 | 1.8 | 28.7 | 0.0 | 0.0 | 26.2 | 0.0 | 0.0 | 0.0 | **57** |
| 04-Mar-14 | 30 | 14.3 | 42.2 | 0.0 | 0.0 | 14.6 | 0.0 | 0.0 | 0.0 | **71** |

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# APPENDIX 1: FERTILIZER APPLICATION TO GREAT CENTRAL LAKE

Table 1. 2008 Great Central Lake fertilizer additions. Total = 94,667 litres. One L of fertilizer contains 0.16729 kg of fertilizer type 10:34:0, and 1.12918 kg of fertilizer type 28:0:0.

| Week Number | Application Date | Total L Fertilizer Added per Day |
|---|---|---|
| 1 | 15-May | |
| 2 | 22-May | 8,896 |
| 3 | 29-May | 11,352 |
| 4 | 05-Jun | 11,352 |
| 5 | 12-Jun | 7,965 |
| 6 | 19-Jun | 6,635 |
| 7 | 26-Jun | 7,965 |
| 8 | 03-Jul | 5,310 |
| 9 | 10-Jul | 5,310 |
| 10 | 17-Jul | 5,310 |
| 11 | 24-Jul | 2,655 |
| 12 | 31-Jul | 2,655 |
| 13 | 07-Aug | 2,655 |
| 14 | 14-Aug | 2,655 |
| 15 | 20-Aug | 2,655 |
| 16 | 27-Aug | 2,655 |
| 17 | 03-Sep | 8,642 |

Table 2. 2009 Great Central Lake fertilizer additions. Total = 93,500 litres. One L of fertilizer contains 0.16729 kg of fertilizer type 10:34:0, and 1.12918 kg of fertilizer type 28:0:0.

| Week Number | Application Date | Total L Fertilizer Added per Day | Total L Fertilizer Added per Week |
|---|---|---|---|
| 1 | 5-May-09 | 4000 | |
| 1 | 8-May-09 | 4000 | 8000 |
| 2 | 12-May-09 | 4000 | |
| 2 | 15-May-09 | 4000 | 8000 |
| 3 | 19-May-09 | 4000 | |
| 3 | 22-May-09 | 4000 | 8000 |
| 4 | 26-May-09 | 4000 | |
| 4 | 29-May-09 | 4000 | 8000 |
| 5 | 2-Jun-09 | 4000 | |
| 5 | 5-Jun-09 | 4000 | 8000 |
| 6 | 9-Jun-09 | 4000 | |
| 6 | 12-Jun-09 | 4000 | 8000 |
| 7 | 16-Jun-09 | 4000 | |
| 7 | 19-Jun-09 | 4000 | 8000 |
| 8 | 23-Jun-09 | 4000 | |
| 8 | 26-Jun-09 | 3000 | 7000 |
| 9 | 30-Jun-09 | 3000 | |
| 9 | 3-Jul-09 | 3000 | 6000 |
| 10 | 7-Jul-09 | 1500 | |
| 10 | 10-Jul-09 | 1500 | 3000 |
| 11 | 14-Jul-09 | 1500 | |
| 11 | 17-Jul-09 | 1500 | 3000 |
| 12 | 21-Jul-09 | 1500 | |
| 12 | 24-Jul-09 | 1500 | 3000 |
| 13 | 28-Jul-09 | 1500 | |
| 13 | 31-Jul-09 | 1500 | 3000 |
| 14 | 4-Aug-09 | 1500 | |
| 14 | 7-Aug-09 | 1500 | 3000 |
| 15 | 11-Aug-09 | 1500 | |
| 15 | 14-Aug-09 | 1500 | 3000 |
| 16 | 18-Aug-09 | 1500 | |
| 16 | 21-Aug-09 | 1500 | 3000 |
| 17 | 25-Aug-09 | 1500 | |
| 17 | 28-Aug-09 | 2000 | 3500 |
| | **2009** | **Total** | **93,500** |

Table 3. 2010 Great Central Lake fertilizer additions. Total = 82,000 litres. One L of fertilizer contains 0.16729 kg of fertilizer type 10:34:0, and 1.12918 kg of fertilizer type 28:0:0.

| Week number | Application Date | Total L fertilizer added per day |
|---|---|---|
| 3 | 25-May-10 | 1500 |
| 3 | 27-May-10 | 3000 |
| 4 | 1-Jun-10 | 3000 |
| 4 | 3-Jun-10 | 4000 |
| 5 | 8-Jun-10 | 3000 |
| 5 | 10-Jun-10 | 3000 |
| 6 | 15-Jun-10 | 4500 |
| 6 | 17-Jun-10 | 4500 |
| 7 | 22-Jun-10 | 4500 |
| 7 | 24-Jun-10 | 3000 |
| 8 | 29-Jun-10 | 3000 |
| 9 | 6-Jul-10 | 4500 |
| 9 | 8-Jul-10 | 3000 |
| 10 | 13-Jul-10 | 3000 |
| 10 | 15-Jul-10 | 1500 |
| 11 | 20-Jul-10 | 1500 |
| 11 | 22-Jul-10 | 1500 |
| 12 | 27-Jul-10 | 1500 |
| 12 | 29-Jul-10 | 1500 |
| 13 | 3-Aug-10 | 1500 |
| 13 | 5-Aug-10 | 1500 |
| 14 | 10-Aug-10 | 1500 |
| 14 | 12-Aug-10 | 1500 |
| 15 | 17-Aug-10 | 1500 |
| 15 | 19-Aug-10 | 1500 |
| 16 | 24-Aug-10 | 1500 |
| 16 | 26-Aug-10 | 1500 |
| 17 | 31-Aug-10 | 1500 |
| 17 | 2-Sep-10 | 1500 |
| 18 | 7-Sep-10 | 1500 |
| 18 | 9-Sep-10 | 3000 |
| 19 | 14-Sep-10 | 3000 |
| 19 | 16-Sep-10 | 4500 |
| | **Total** | **82000** |

Table 4. 2011 Great Central Lake fertilizer additions. Total = 63,000 litres. One L of fertilizer contains 0.16729 kg of fertilizer type 10:34:0, and 1.12918 kg of fertilizer type 28:0:0.

| Week number | Date | Total L fertilizer added per day | Total L fertilizer added per week |
|---|---|---|---|
| 9 | 7-Jul-11 | 4500 | 4500 |
| 10 | 12-Jul-11 | 3000 | |
| 10 | 14-Jul-11 | 3000 | 6000 |
| 11 | 19-Jul-11 | 1500 | |
| 11 | 21-Jul-11 | 1500 | 3000 |
| 12 | 26-Jul-11 | 1500 | |
| 12 | 28-Jul-11 | 1500 | 3000 |
| 13 | 2-Aug-11 | 1500 | |
| 13 | 4-Aug-11 | 1500 | 3000 |
| 14 | 9-Aug-11 | 1500 | |
| 14 | 11-Aug-11 | 1500 | 3000 |
| 15 | 16-Aug-11 | 1500 | |
| 15 | 18-Aug-11 | 1500 | 3000 |
| 16 | 23-Aug-11 | 1500 | |
| 16 | 25-Aug-11 | 1500 | 3000 |
| 17 | 30-Aug-11 | 3000 | |
| 17 | 1-Sep-11 | 1500 | 4500 |
| 18 | 6-Sep-11 | 1500 | |
| 18 | 9-Sep-11 | 3000 | 4500 |
| 19 | 13-Sep-11 | 3000 | |
| 19 | 15-Sep-11 | 4500 | 7500 |
| 20 | 20-Sep-11 | 4500 | |
| 20 | 22-Sep-11 | 4500 | 9000 |
| 21 | 27-Sep-11 | 4500 | |
| 21 | 29-Sep-11 | 4500 | 9000 |
| | | **TOTAL** | **63,000** |

Table 5. 2012 Great Central Lake fertilizer additions. Total = 105,000 litres. One L of fertilizer contains 0.16729 kg of fertilizer type 10:34:0, and 1.12918 kg of fertilizer type 28:0:0.

| Week number | Date | L of fertilizer added per day |
|---|---|---|
| | 03-May-12 | 1500 |
| | 08-May-12 | 1500 |
| | 10-May-12 | 1500 |
| | 15-May-12 | 3000 |
| | 17-May-12 | 3000 |
| | 22-May-12 | 3000 |
| | 24-May-12 | 3000 |
| | 29-May-12 | 3000 |
| | 30-May-12 | 3000 |
| | 05-Jun-12 | 3000 |
| | 07-Jun-12 | 3000 |
| | 12-Jun-12 | 3000 |
| | 14-Jun-12 | 3000 |
| | 19-Jun-12 | 1500 |
| | 21-Jun-12 | 1500 |
| | 26-Jun-12 | 1500 |
| | 28-Jun-12 | 1500 |
| | 03-Jul-12 | 1500 |
| | 05-Jul-12 | 3000 |
| | 10-Jul-12 | 3000 |
| | 12-Jul-12 | 3000 |
| | 17-Jul-12 | 3000 |
| | 19-Jul-12 | 3000 |
| | 24-Jul-12 | 3000 |
| | 26-Jul-12 | 3000 |
| | 31-Jul-12 | 3000 |
| | 02-Aug-12 | 3000 |
| | 07-Aug-12 | 3000 |
| | 09-Aug-12 | 3000 |
| | 14-Aug-12 | 3000 |
| | 16-Aug-12 | 3000 |
| | 21-Aug-12 | 3000 |
| | 23-Aug-12 | 3000 |
| | 28-Aug-12 | 3000 |
| | 30-Aug-12 | 3000 |
| | 04-Sep-12 | 3000 |
| | 11-Sep-12 | 3000 |
| | 18-Sep-12 | 3000 |
| | 25-Sep-12 | 3000 |
| | **Total** | **105000** |

Table 5. 2013 Great Central Lake fertilizer additions. Total = 109,500 litres. One L of fertilizer contains 0.16729 kg of fertilizer type 10:34:0, and 1.12918 kg of fertilizer type 28:0:0.

| Date 2013 | L of fertilizer added per day |
|---|---|
| 09-May-13 | 3000 |
| 14-May-13 | 1500 |
| 16-May-13 | 1500 |
| 21-May-13 | 3000 |
| 23-May-13 | 3000 |
| 28-May-13 | 3000 |
| 30-May-13 | 3000 |
| 04-Jun-13 | 3000 |
| 06-Jun-13 | 3000 |
| 11-Jun-13 | 3000 |
| 13-Jun-13 | 3000 |
| 18-Jun-13 | 3000 |
| 20-Jun-13 | 3000 |
| 25-Jun-13 | 3000 |
| 27-Jun-13 | 1500 |
| 02-Jul-13 | 1500 |
| 04-Jul-13 | 1500 |
| 09-Jul-13 | 1500 |
| 11-Jul-13 | 3000 |
| 16-Jul-13 | 3000 |
| 18-Jul-13 | 3000 |
| 23-Jul-13 | 3000 |
| 25-Jul-13 | 3000 |
| 30-Jul-13 | 3000 |
| 01-Aug-13 | 1500 |
| 06-Aug-13 | 0 |
| 08-Aug-13 | 0 |
| 13-Aug-13 | 3000 |
| 15-Aug-13 | 3000 |
| 20-Aug-13 | 3000 |
| 22-Aug-13 | 3000 |
| 27-Aug-13 | 3000 |
| 29-Aug-13 | 3000 |
| 03-Sep-13 | 3000 |
| 05-Sep-13 | 3000 |
| 10-Sep-13 | 3000 |
| 12-Sep-13 | 3000 |
| 17-Sep-13 | 3000 |
| 19-Sep-13 | 3000 |
| 24-Sep-13 | 3000 |
| 26-Sep-13 | 3000 |
| 01-Oct-13 | 3000 |
| **Total** | **109500** |